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APRIL ★ 1944
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How Concrete Serves in Navy Medical Center

The Navy Medical Center near Washington is a gleaming white monumental group dominated by a 20-story tower. A facing material which would provide architectural beauty and resist soiling and weathering was a requirement of the designers.

Large precast architectural concrete panels used for enclosing the walls aided in speeding construction time. 400,000 sq.ft. of these concrete facing panels were used in 500 different shapes and sizes.

A majority of the buildings in the group have reinforced concrete frame with the exception of the tower itself.

To help get the maximum service which Architectural Concrete can render, the Portland Cement Association's concrete technicians are available to assist designers and builders of war structures. Ask for this service.

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The buildings in the Navy Medical Center group were designed by the Bureau of Yards and Docks, Rear Admiral Ben Moreell, Chief of Bureau. Frank W. Southworth, project manager for the Bureau of Medicine and Surgery, Ross T. McIntire, Surgeon General of the Navy. Paul P. Cret of Philadelphia, consulting architect. John McShain, Inc., contractor. Capt. Hugo C. Fisher, U.S.N., officer-in-charge for the Navy Department.

BUY WAR BONDS TO SPEED VICTORY

BY-LINES

ORHAN EMRE

Orhan Emre received his B. S. degree in Istanbul, Turkey, in 1934, his M. S. degree from the University of Illinois in 1936, and his professional degree from Caltech in 1940. He is now working for his Ph. D. degree in civil engineering. From 1936 through 1939 he was with a contractor in Ankara, Turkey, working in structural design on a building project.

FRITZ KARGE

Fritz Karge received his B. S. degree from Caltech in 1918 while on a leave of absence from the Union Oil Company. After his graduation he was put in charge of civil engineering and also survey and mapping during that important period of expansion in the oil industry. Mr. Karge is now a pipeline engineer with the same company.

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Mr. Kinsey received his B. S. degree in engineering and economics from Caltech in 1926. He has engaged in design and safety engineering and fire and accident protection engineering. Since 1938 he has been manager of the engineering department of Cosgrove & Company, Inc., and has lectured for two years at the War Training Program at the University of Southern California.

SPYRO KYROPOULOS

Spyro Kyropoulos received his Ph. D. degree in chemistry at the University of Leipzig in 1911. He was employed in several European universities in research and the teaching of applied physical chemistry and fluid mechanics. From 1932 to 1936 he was a consulting physicist in the oil and automotive industry. Since 1937 Dr. Kyropoulos has been a research fellow at the Institute.

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The Truth Shall Make You Free

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ENGINEERING AND SCIENCE MONTHLY

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Monthly

Vol. VII No. 4 April, 1944

The Month in Focus

ONE OF THE recurring questions in engineering education is the place of highly specialized training. The armed services, in their various college programs, have answered this question in a variety of ways; but in each case the answer has been dictated by a definite and specific need. Doubtless some of the changes which war training programs have brought about in engineering curricula can be advantageously retained in postwar engineering education. But since in times of peace engineering students are trained for general fields rather than for the needs of a single company, it is doubtful whether a high degree of specialization during undergraduate years is a desirable feature.

In general, industry has expressed itself as favoring broader, fundamental engineering education during the first four years. Beyond this period industry itself is probably best equipped to give or to supervise the specialized training which is demanded of its engineering personnel. This does not, of course, eliminate the necessity of graduate training in college; but such training best serves its purpose with men who are to occupy research positions and positions involving highly specialized technical skill.

Far too many engineering students pass through their undergraduate years without a sufficient realization of the relationship between their courses and the ultimate character of the professions for which they are preparing themselves. This is unfortunate—unfortunate for the students and unfortunate for industry.

Some engineering colleges feel that they have met this difficulty through cooperative systems in which the student alternates classroom and laboratory work with practical experience in industry. Some institutions encourage their students to take summer work in the appropriate engineering fields. It is beside the point here to attempt to decide which of these systems is the better. The fact is that whatever the system (or lack of system), the situation can be greatly improved by closer and more sustained cooperation between colleges and industry. Under normal conditions, the college should concentrate the four years of undergraduate training on engineering and science fundamentals. Industry, for its part, should begin its indoctrination programs to stimulate interest early in the students' college career; and it should become acquainted with the men at about the time when they are choosing the engineering field in which they wish to work, not waiting until they are seniors on the eve of graduation and looking for jobs.

At present these ideas cannot be put into practice to the fullest extent. The future of men in the service training programs is determined, at least for the duration. (The special problems which will grow out of their situation at the end of the war will be serious; but they should not affect the permanent character of engineering education, since in the nature of things they will be of limited duration). For civilians, the principal deterrent is the draft situation. Most students graduate from college at the age of 20 to 22. Present Selective Service regulations (as of March 1) make it difficult to employ and hold these men. Under the quota system of student deferment the California Institute of Technology, for instance, is allowed deferment for only about 47 students; and it is doubtful whether industry will be in a position to employ these men upon graduation. The difficulty is that while they are deferred until the end of their undergraduate work, there is no assurance that deferment will be continued so that they can take positions in industry. In February, for example, several companies canceled offers which they had made to graduating seniors because it was impossible to obtain further deferment for them. Industry is not likely to be willing to embark on a program of closer and more intensive cooperation with engineering colleges unless there is reasonable assurance of results in the way of promising recruits.

Nevertheless, though such a program of closer cooperation may be impracticable at the present time, it is still a highly desirable end to work for as part of the inevitable readjustments which will be made in engineering education when the war is won.

Front view of School of Language, History and Geography. The stone writing on top is a quotation from Kemal Ataturk, "The Truest Guide in Life is Knowledge." The architect was the late B. Taut.

Modern Building Construction in Turkey

". . . I saw [in Turkey] the most advanced type of building construction."—Wendell L. Willkie in "One World."

BY ORHAN M. EMRE

WHEN Turkey came out of the first World War she was faced with the problems of a country neglected in many ways. Among many shortcomings the lack of modern buildings was one of the most acute. There were still in existence many beautiful and well-built structures such as palaces, mosques and aqueducts which were priceless in historic value, but a country trying to keep up with the modern world could not afford to conduct governmental works, business, education, and recreation in obsolete, unsafe, ill-ventilated and out-of-date buildings. This lack of modern facilities was one of the most serious of all problems.

The postwar democratic government of Turkey did not hesitate to hire the best available city-planning experts; and a systematic plan for the remodeling of the cities was organized. According to this plan no buildings located on future public grounds were allowed to be remodeled or enlarged, so that after their useful life had expired the areas would be available for parks, playgrounds, community apartment units or whatever other programs were assigned for future development. Naturally the granting of new building permits on such areas was out of the question. This method worked very satisfactorily, and part by part the general plan was fitted together like a jig-saw puzzle.

WIDESPREAD USE OF CONCRETE

Most of the old buildings were either of wood-frame or brick and I-beam joist construction. The wood-frame buildings had a comparatively short life and were subject to heavy damage or destruction by fire. It was after World War I, and under the new governmental regime, that reinforced concrete became a very popular type of construction, and the new program made full use of it. Among the reasons for the wide use of concrete were that when properly designed it made a lasting fire- and earthquake-resistant structure, and also that the larger material constituents were cement and sand, which are found in good quality and abundance in the country. Until recent years Turkey imported her entire requirements of steel.

Today the most widely used type of building construction is the reinforced concrete frame with brick or stone filler walls. The density of population in the cities does not as yet (and probably will not for some time in the future) call for a vertical expansion in building construction, so that few buildings are more than three or four stories high. A four-story reinforced concrete frame is, with due care and design, adequate for a seismic load of one-tenth gravity. Turkey is located in the seismic belt and earthquakes of major proportions are of frequent occurrence.

Wood-frame construction is not permitted in the cities because of the fire hazards of peace and war. Wood roof trusses may be used in residential buildings, but all large public buildings have to use a non-inflammable roof construction and a suitably large bomb shelter in the basement.

MOST MATERIALS IMPORTED

Most of the secondary items that enter into the makeup of a modern building are imported. With the installation of the steel manufacturing center in Karabuk, steel is now being provided locally; but goods like linoleum, heating and ventilating equipment, electrical apparatus

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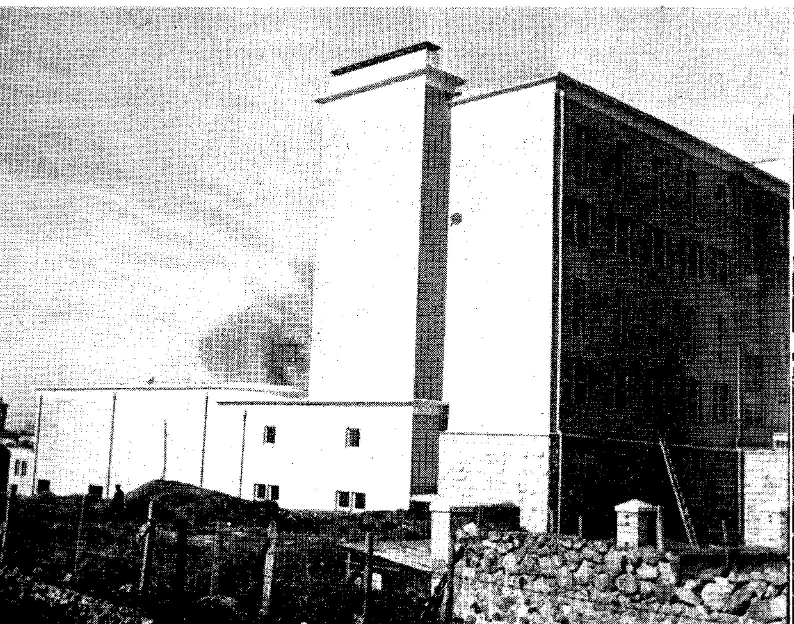
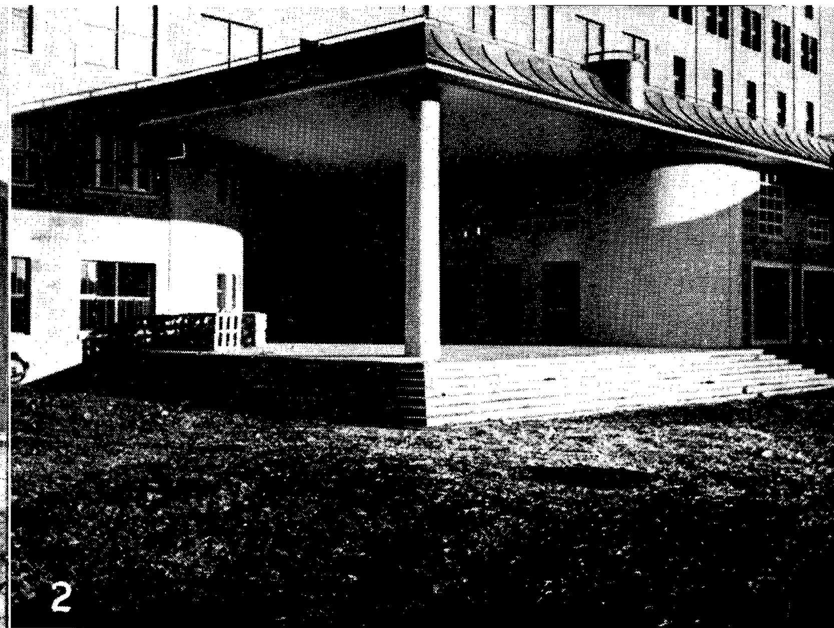
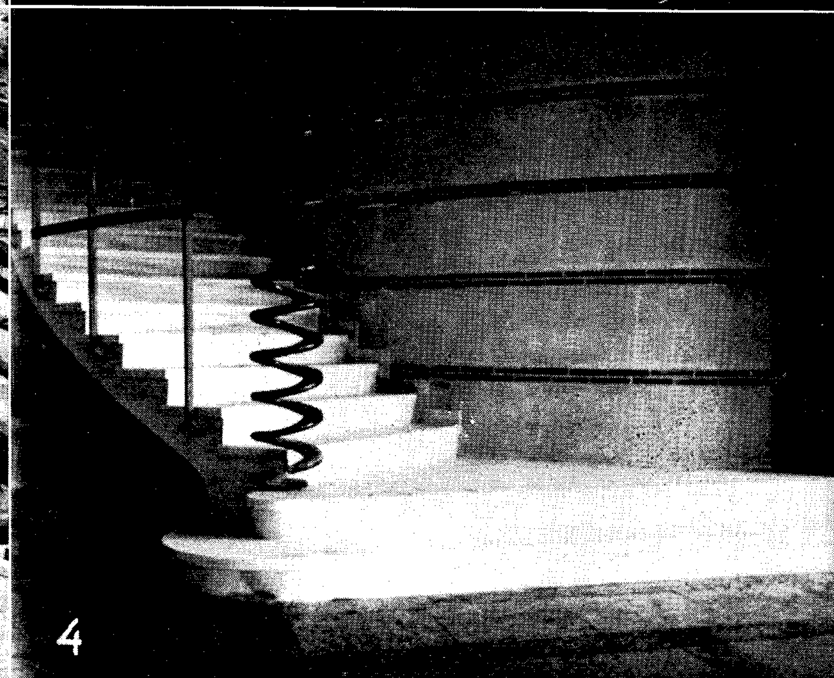
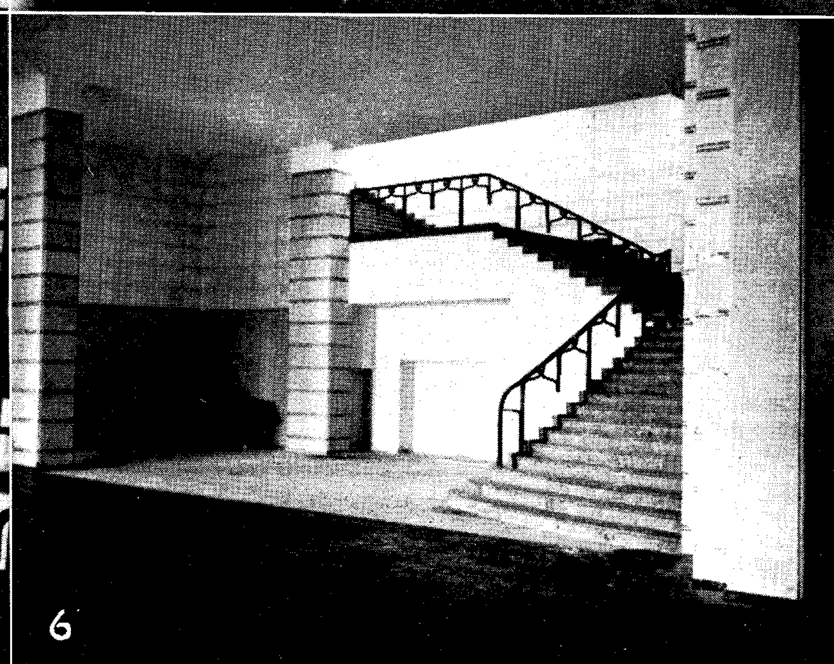
Illustrations on Facing Page

1. View of the school from northeast. Note the junction of face stone with plaster. The layers of stone alternate with layers of face brick bonded with white mortar. 2. Main entrance facing south. Note speaker's stand on copper rim of balcony. 3. Workman placing hollow concrete blocks for joist construction. Note hooks on column bars—due to building code regulation. 4. Reinforced concrete stair. Each story of the building has a different shade of color









on the walls. 5. Stair leading to the balcony of the main lecture hall. Steps are of white marble of high density. The wall is of Leski stone with bands of glazed ceramic of greenish-blue. 6. Main hall. Floor of Hereke stone, a beautiful conglomerate taking a high polish.

Equipment for an Alkylation Plant for Production of High-Octane Gasoline

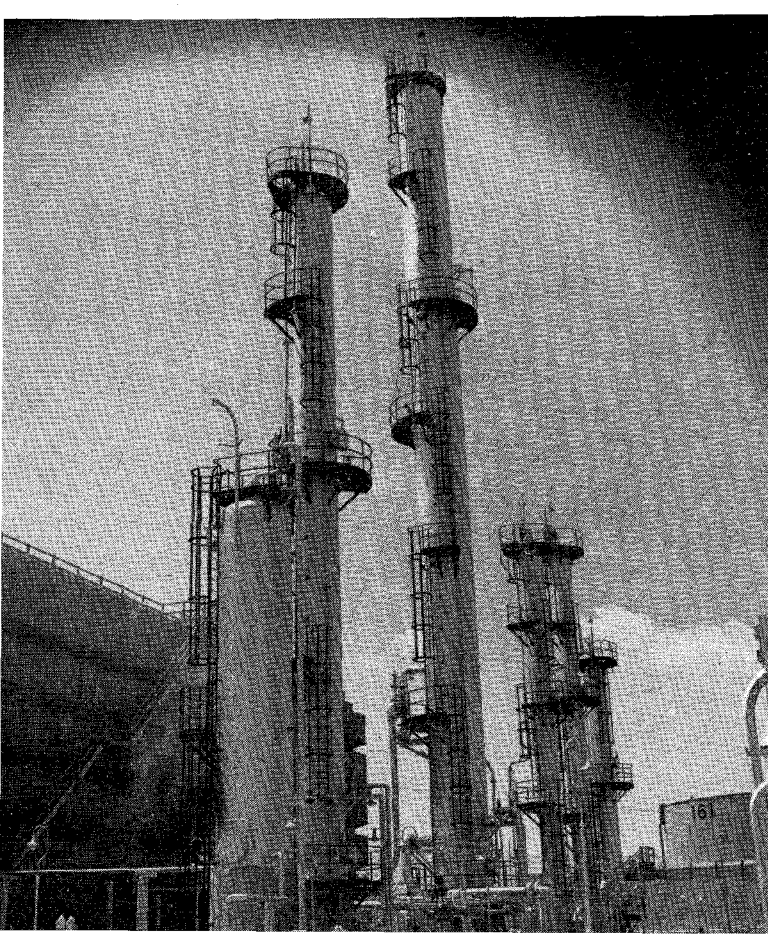
BY FRITZ KARGE

THE multiplication of the country's fighting, bombing and transporting airplanes has brought with it a greatly increased demand for the best gasoline that can be produced at a reasonable cost. For the time being, a gasoline of 100 octane rating complies with this requirement. Such a gasoline gives to the planes better performance, particularly at high altitudes, and more power and speed with lighter engines than a good grade of motor gasoline of 70 octane rating. It has been predicted that in the future airplane fuels of 120 to 130 octane rating will be demanded and made available. As a matter of fact, such gasolines can now be, and have been, produced. We can speak of a better than 100 rating since this arbitrary standard was established when it seemed the ultimate goal.

Several processes have been developed during the last five or six years, the end product of which is either a 100 octane gasoline or one of a somewhat lower rating, and many plants have been built during the last two years and many others are in the course of construction, all for the production of aviation gasoline. Most of them use the alkylation method.

ALKYLATION

Alkylation is a process by which, through the action of a catalyst, iso-butane, a saturated branched-chain hydrocarbon is combined with a low boiling point olefin, an unsaturated branch or straight chain hydrocarbon, to form a heavier saturated branched-chain hydrocarbon.



The hydrocarbon, so produced, makes an excellent aviation fuel when blended with certain other hydrocarbons to the desired volatility characteristics. It has an octane rating of at least 93. It is highly susceptible to lead, so that only small additions of tetraethyl lead raise its octane rating to 100. It has a very low sulphur content, a high calorific value and it is not very sensitive to different engine conditions.

The catalyst employed in most alkylation plants is a 96 to 100 per cent sulphuric acid. Hydrofluoric acid is also used and other catalysts might be introduced as time goes on.

It is one of the romantic achievements of the petroleum industry that this almost ideal aviation fuel is produced out of charging stocks that a few years ago were considered a nuisance because of their high volatility, making them unfit for use in motor fuel.

THE PROCESS

The purpose of this article is briefly to outline the equipment and apparatus for an alkylation plant, using sulphuric acid as a catalyst. It is beyond the scope of the article to give detailed information of the process itself. It will be necessary, however, to allude to steps in the process in order to explain the purpose of various equipment items. It is intendedly not a reference paper to serve as a basis on which such a plant might be designed.

A plant will be chosen producing from 2500 to 3000 barrels of alkylate per 24-hour day, giving, after blending with an equal volume of other hydrocarbons, from 210,000 to 250,000 gallons of aviation gasoline, enough for approximately an equal number of air miles for all but the most powerful planes. It is assumed that the raw materials, butane, iso-butane, and butene, are available from a catalytic petroleum cracking plant, already in existence or under construction. These cracking plants, many of which have been built, can produce large quantities of the hydrocarbons necessary for the alkylation process without lowering the quality of the motor gasoline or heavier fractions which they produce. The crude oil and natural gas that flow from the wells with the oil contain no olefins. The olefins for alkylation must be made by a cracking process.

The charging stocks for an alkylation plant are not usually produced in pure form. Other hydrocarbons are admixed. They must be removed before alkylation since they affect the desired reaction adversely and cause a greater acid consumption. To purify the raw stock by the removal of all undesirable admixtures requires often as much equipment as the alkylation process itself.

Iso-butane is seldom available in large enough quantities, but butane is. To change this straight chain hydrocarbon to the branched-chain fraction of the same number of carbon and hydrogen atoms an isomerization plant often becomes one of the parts of an alkylation plant and special equipment is required. The alkylate itself must be finally purified, the catalytic treatment leaving varying amounts of uncombined raw stocks in the alkylate.

The reaction with the sulphuric acid is most economical when the iso-butane-butene ratio is held at about five to one. Approximately four parts of the iso-butane appears then uncombined in the alkylate and must be removed, again to enter the feed stream. This also requires equipment. Finally a small amount of acid is carried over from the reaction, which must be eliminated by a neutralizing caustic wash.

The equipment in most alkylation plants divides itself therefore roughly into the following categories: Equipment for purifying the feed stock; alkylation reaction equipment and equipment for purifying the alkylate. A brief description of the various equipment items must suffice.

PURIFICATION

For the removal of undesired hydrocarbon fractions before and after alkylation, towers, or bubble columns, as they are often called, are employed. They are cylindrical vertical steel vessels of a variety of dimensions. Here might be a number of small towers, three feet in diameter and 30 to 100 feet high; there others six to eight feet in diameter and 30 to 80 feet high. Usually a larger tower, nine to 10 feet in diameter and 140 to 160 feet high, is required to remove the uncombined iso-butane from the norma-butane and alkylate.

In simple words, these towers effect an intimate contact between a hydrocarbon vapor and a hydrocarbon liquid and a separation due to differences in boiling points. The vapor rises upwards, the liquid trickles downwards. The contact is brought about by horizontal shelves or trays and an arrangement on them of holes, chimneys, bubble caps, weirs and downcomers, by means of which the vapor is forced to bubble through the liquid. The size of the towers, number of trays, operating pressures and temperatures depend upon the desired interaction of vapor and liquid and upon the character of the stocks acting upon each other. In the interaction of vapor and liquid under controlled temperature and pressure conditions vapor fractions are absorbed by the liquid or liquid fractions are liberated to the vapor.

CATALYSIS

The mixing of the sulphuric acid with the hydrocarbon, approximately in equal proportions, is carried on continuously in so-called contactors, the design of which varies for different users. One type is provided with a mixing impeller rotated by steam turbines or electric motors. The contactor is a vertical vessel and a tube bundle extends through its interior except for the space housing the impeller and certain passages for the liquid. The impeller circulates the mixture at the high rate of about 50,000 gallons per minute. The catalytic reaction has been found to take place most economically at a temperature of from 28 degrees to 50 degrees F., considerably below ordinary atmospheric temperatures. A cooling medium, usually ammonia, is therefore circulated through the tube bundle to remove the heat of reaction and mixing in the contactors, after pre-cooling the hydrocarbon in an ammonia chiller. Refrigeration equipment is therefore needed. For a plant of 2500 barrels of alkylate per day a daily refrigerant capacity of about 750 tons is sufficient. Whether to employ the ammonia compressor or ammonia absorption process depends largely upon the relative availability and cost of electric power and steam, the compressor process calling for more electric power but less steam.

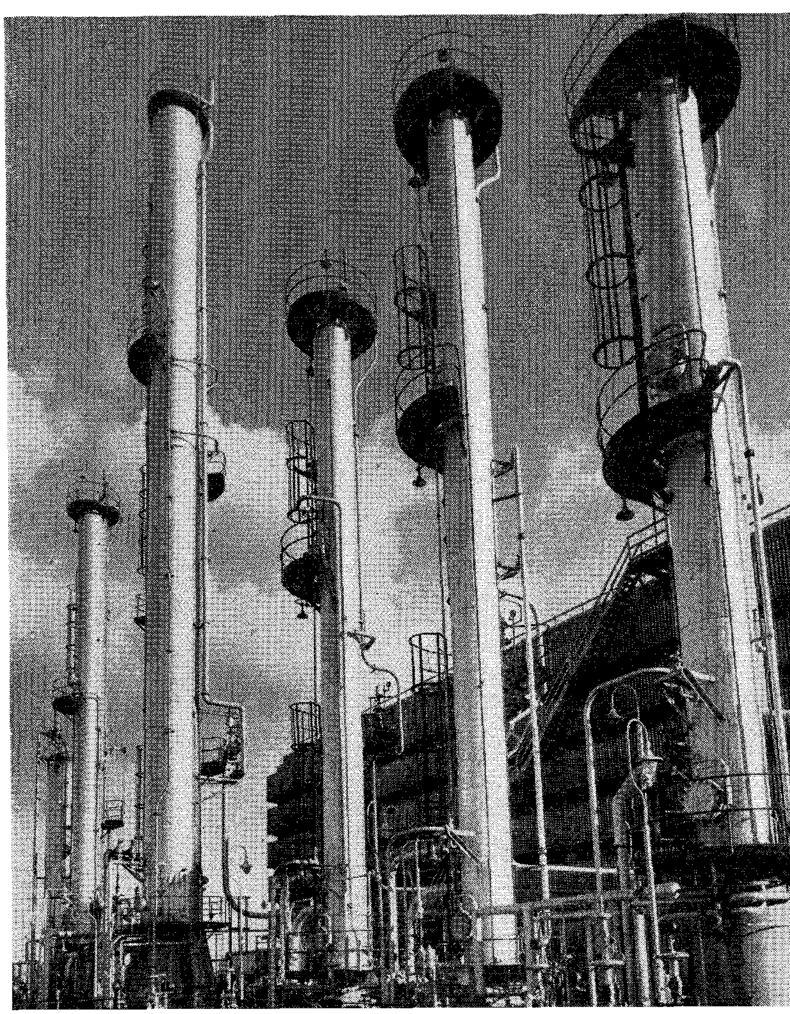
The stream of the sulphuric acid-hydrocarbon mixture from the contactors is directed to acid settlers, horizontal vessels equipped with partial trays. The separation takes place because of the much higher specific gravity of the acid.

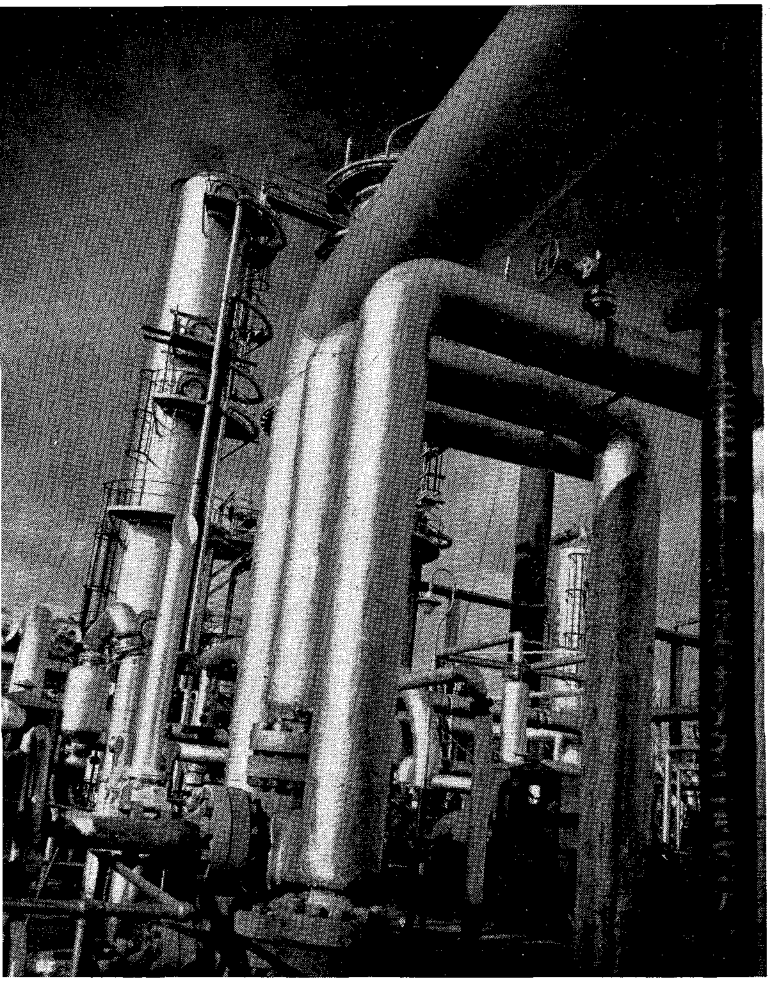
The isomerization process through which butane atoms are rearranged to form iso-butane usually employs anhydrous hydrogen chloride as an activator for a catalyst, and special equipment must be provided.

As pointed out, all reactions must be brought about at certain temperatures, depending upon the reactions desired and the reacting materials. In their course of travel through the plant the liquids must be heated perhaps several times, to reacting or vaporizing temperatures, steam being largely employed as the heating medium. The vapors must be cooled to condensation, water serving as cooling medium. Wherever possible, however, hot liquids that must be cooled are made to give up heat to colder liquids in need of heating, through the use of tube interchangers. Similar shell-tube equipment is provided for heating, vaporizing, cooling and condensing.

Storage tanks are required for the charging stocks, for some intermediate cuts and for the finished product. Pressure tanks in the shape of spheroids of appropriate capacity are often provided for the charging stocks in order to prevent evaporation. A number of accumulator tanks, horizontal or vertical steel vessels of sufficient volumetric and pressure capacity, must be installed to hold the liquid hydrocarbons in their various stages.

Pumps are needed for handling the various liquids in their progressive flow through the plant. Many centrifu-





gal pumps are used whenever the flow rate and differential pressure conditions suit their basic hydraulic characteristics. For small pumping rates with high-pressure differentials reciprocating steam simplex pumps offer the best service. For the acid, rotary pumps are often chosen. Cooling water is efficiently handled by centrifugal pumps. Whether to drive the centrifugal and rotary pumps by electric motors or by steam turbines depends largely upon the availability and relative cost of these media, and the need for low pressure exhaust steam in other parts of the refinery. In many plants electric motors are installed as operating prime movers, and steam turbines are provided for standby pumps, to be used in case of failure of the electric power supply, and when a pump requires overhauling or repacking.

Large quantities of cooling water must be supplied, requiring usually a cooling tower for atmospheric or for forced draft cooling, with the necessary pumps. An alkylation plant of the size mentioned will need approximately 10,000 gallons per minute of cooling water. The choice of the tower will be determined largely by the prevailing minimum and maximum atmospheric temperature conditions.

PIPING

Interconnecting pipe lines for hydrocarbon liquids and vapors, for steam, condensate, water, catalysts, compressed air, and waste materials constitute one of the principal equipment items of the plant. In size they might vary from tubes of one-quarter-inch diameter for instrument air to others of 24-inch diameter for cooling water, some operating by gravity, others under 500 to 600 pounds per square inch, the majority between these extremes.

Steel is the pipe material used most. Copper tubing, because of its greater flexibility and corrosion resistance, handles air to control instruments. Short runs of stainless steel tubing are employed in the hydrogenchloride circuit. For large cooling water lines transite pressure pipe has found favor during the last few years. Seamless pipe is often specified for hydrocarbon and high pressure steam lines. For other services lapwelded or continuous electric weld pipe meets the requirements. Many varieties of shut-off and control devices, carefully chosen for the service, must be provided to block the flow to and from tanks, accumulators, towers, heating and cooling equipment; to connect the pumps to the maze of hydrocarbon pipe lines and to the live and exhaust steam mains, and to make possible the shunting of streams to the various units of the plant. Gate valves, check valves, globe valves, needle valves and lubricated plug cocks must be located according to services required. All such fittings over two inches in size are usually flanged, those of smaller sizes screwed.

Desuperheaters might be considered another type of equipment belonging to the piping system. Since superheated steam is not an efficient heating medium, they are installed in heating-steam lines wherever they take off lines carrying superheated steam to prime movers. Condensate pots, steam traps, and drums in which high-pressure condensate is partially flashed into lower pressure steam are also parts of the piping system, as well as separators, ejectors, and exhaust heads.

A sewer system covers all parts of the plant to carry away any hydrocarbon leaks, condensate drips, water for washing floors, etc. In buildings cast iron pipe is used, often with lead joints; outside of buildings, vitrified clay pipe with cement joints, and with acid proof joints below the highest point at which acid drips might originate. The sewer usually leads to a separator where the water is freed of hydrocarbons and acid.

INSTRUMENTS

It has been said truly that a modern refinery could not be operated efficiently and economically without automatic control and recording devices. Flow rates, temperatures and pressures must be maintained continuously and with very small variations at so many points in a plant that only an army of men could do the work, and not very well at that. The many kinds of instruments, developed as demand arose, are insensible to moods, fits of inattentiveness, varying weather conditions, and other factors influencing the constancy of application that would be required of human beings. Instruments make it possible to operate so large and intricate a refinery plant with only three or four men on a shift and always to have a complete and faithful performance record available.

A list of the more important of such devices reads something like this: Flow and liquid level controllers, indicators and recorders, gage glasses, pressure gages, recorders and controllers, back-pressure controllers, and temperature recorders and controllers. Temperatures can be determined in any necessary part of any equipment through the installation of thermocouples, the lead wires of which end in a single panel of the instrument board. Thermometers, installed in wells, give local temperatures. Pressure relief valves are employed to safeguard the equipment against overpressures. All but the locally mounted instruments have their indicating and recording parts installed on an instrument board, often centrally located near the pumps. The board in the plant under

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ACCIDENT PREVENTION
and the conservation of manpower

BY J. E. KINSEY

THE subject of accident prevention in industry is not new. Yet recent surveys indicate that of our country's 200,000 industrial plants, less than 13 per cent have adequate safety programs. The occupational injury rate has been high throughout American industrial history. During the earlier years, relatively little or no attention was given to the conservation of manpower. However, with the formation of large corporations which brought together greater numbers of men and women into one plant, some attention was focused on the increasing human wastage through accidents. Even then, the first reaction was to assist the victims financially after the accident had happened, rather than to stop the accidents which were the cause of their plight. Under the common law system, the injured had very little chance to recover damages. If the employer could prove either contributory negligence on the part of the injured, negligence of a fellow worker, or the assumption of risk by the injured, the employer had no obligation.

WORKMEN'S COMPENSATION LAWS

The realization of the fallacy in such a system brought forth the employer's liability laws. These laws did not establish the burden of proof but only permitted greater ease of recovery when the employer was proved to have been negligent. In 1911 state governments began adopting workmen's compensation laws, and today such laws have been passed in all states except Mississippi. There is wide variation between the laws of the different states, but all of them tend to accomplish the same end:

1. They eliminate negligence as a defense against paying compensation by the employer. The employer pays compensation regardless of the cause of the accident.
2. They provide medical care in order to hasten the return of the worker to his job.
3. They establish a reasonably exact method of computing the monetary benefit to be paid to the injured.
4. They provide benefits at least during a period of readjustment in cases of permanent disability and death; and in some states they provide continued payments to the injured or to the widow and children of the deceased workman.

Workmen's compensation legislation provided the first real stimulus to industrial accident prevention and is primarily responsible for the movement as it was known before Pearl Harbor. The only certain way to avoid paying for accidents is to prevent them.

ACCIDENT PREVENTION AN INVESTMENT

Let us forget momentarily the wartime emergency and deal with accident prevention on a peacetime basis and entirely from the dollar and cents viewpoint. This phase of accident prevention should prove to be of greatest interest to those who are charged with the duties of controlling the finances of industrial concerns; and this discussion may suggest a field for investment which heretofore may have been overlooked. Few individuals would overlook an opportunity to invest their company's money where they were guaranteed a 20 per cent, 15 per cent, or even 10 per cent return, whether it be in their own plant or in the open market. Still there are many who are passing up an opportunity to earn 25 per cent, 50 per cent, 100 per cent, or even more on an investment over which they have complete and unrestricted control.

How does one determine the economics to be derived from accident prevention when considered as an investment?

First. Those in control must be convinced that accidents can be prevented. Upon close examination of the problems at hand, this should not be difficult.

Second. There must be a willingness and readiness to spend money in the same manner as it would be spent for the investment of equipment in the production of the commodities sold by the corporation. These expenditures include not only the cost of guarding machinery and the cost of rearranging physical equipment, but also the payroll expended on safety engineers and the entire line organization in proportion to the time actually spent by these persons on safety and safety training.

Third. It is necessary to establish a reliable method of determining the true and full cost of accidents. It may be a surprise to learn that there are many aspects to establishing the cost of accidents. At first one may think, "This is simple—you merely take the premium paid, deduct the dividend returned (if any), and then you have the net cost," or if self-insured, "Merely add losses paid to cost for the self-insured bond, to clerks' salary for administration, and to a few more items of direct expense, and you have the net cost."

True, this is the exact figure the auditors enter on the books, but it is not the net cost of accidents, and in most plants it is not even 20 per cent of the cost; in many plants it represents less than 10 per cent of the true cost. How then is it possible to determine the true cost of accidents? Space does not permit the full treatment of this subject, but several items of indirect cost may be suggested which should be taken into account in practically all industrial injury accidents. These are taken from H. W. Heinrich's work on industrial accident prevention:

1. Cost of lost time of injured employee.
2. Cost of time lost by other employees who stop work out of curiosity, out of sympathy, to assist injured employee, or for other reasons.
3. Cost of time lost by foreman, supervisors, or other executives in assisting the injured employee, investigating the cause of the accident, arranging for the injured employee's production to be continued by some other employee, selecting, training or breaking in a new employee to replace the injured employee, and preparing state accident reports or attending hearings before the Industrial Accident Commission.
4. The cost of the time spent on the case by first-aid attendant and hospital staff, when not paid for by the insurance carrier.
5. The cost due to injury to the machine, tools, or other property or to the spoilage of material.

6. The incidental cost due to interference with production, failure to fill orders on time, loss of bonuses, payment of forfeits, and other similar causes.

7. The cost to employer under employee welfare and benefit systems.

8. The cost to employer in continuing the wages of the injured employee in full, after his return, even though the services of the employee (who is not yet fully recovered) may for a time be worth only about half of their normal value.

9. The cost due to the loss of profits on the injured employee's productivity, and on idle machines.

10. The cost of subsequent injuries that occur in consequence of the excitement or weakened morale due to the original accident.

11. The overhead cost per injured employee—the expense of light, heat, rent, and other such items, which continue while the injured employee is a non-producer.

In addition to all of these points there are others that might well receive consideration, although those items which have been considered here clearly outline the vicious and seemingly endless cycle of events that follow in the train of accidents.

DIVIDENDS FROM ACCIDENT PREVENTION

Returning to the discussion of the idea of investment in safety: if the reader is convinced that accidents can be prevented, if he is willing to spend some money, and if he has learned to measure the true cost of the accidents both direct and indirect, then, and only then, can he be qualified to present his investment idea to top management and demand its fullest support and cooperation. The most vivid proof that investment in accident prevention pays high dividends is illustrated by a few specific examples. The first example may be taken from information developed by the United States Steel Corporation covering the period 1906 to 1938. The figures presented here were included in a letter written to the author a year or so ago by Arthur H. Young, former vice-president of the United States Steel Corporation and now a lecturer in industrial relations at the California Institute of Technology. In order to make the points clear, parts of Mr. Young's letter follow:

"In steel, we had access to a meticulously kept statistical record of many years, which included, in addition to accident frequency and severity rates, a record of all sums spent for safety. This latter included salaries, office and travel expense of regular staff members; time, and other costs of workmen's and foremen's committees; appropriations strictly for safety alone; proportionate costs for safety in appropriations increased over plant needs, when such additional cost was exclusively for safety; plant medical services and hospital costs, etc., about everything the auditors could charge to safety. The total of this, cumulative from 1906 to 1938 inclusive, was $29,595,770. Our frequency data listed every accident causing lost time beyond the turn or tour on which the accident occurred.

"Severity was very crudely tabulated in the earlier years, and to use cumulative figures, I had to continue the original classification. It was a simple division into two classes—'Serious' and 'Non-serious.' 'Serious' included all injuries causing more than 35 days temporary disability, or involving permanent disability to any degree. 'Non-serious' were injuries involving no permanent disability, and less than 35 days temporary disability.

"Each year after 1905 the U. S. Steel Corporation published a statement of 'accidents prevented during the year' in these two classifications. The method of computations was to multiply the average number of employees in each year by the frequency rate for each classification that prevailed in 1905, then subtract the actual number of injuries, the remainder theoretically being the number of injuries prevented by bettered safety practices.

"The number of serious injuries prevented, 1906-1938 inclusive, so computed was 83,392.

"The average cost of compensation and medical service of serious accidents over the period was $612; therefore the theoretical saving was $51,035,904. Similarly, 676,-720 non-serious accidents were prevented, and I used a flat $10.00 as a conservative cost of compensation and medical service, or $6,787,200 saving, the total being $57,823,104, or about twice the cost of safety.

"I also discussed with you the cost of labor turnover as influenced by the 83,392 serious accidents prevented, assuming each accident meant replacement of a worker.

"On this, the sky is the limit—I used $100 as a low mean between the two figures, $50 and $200, mentioned in the Hoover 'Waste in Industry' report of several years ago. At $100 per each, there is a by-product valued at $8,339,200.

"In a bulletin of the Department of Commerce dated September, 1930, there is a discussion of many other factors of cost of accidents: idle machinery; distraction of other workmen; loss of time by other workmen giving attention to injured, etc. It surely is a long and complicated (and somewhat theoretical) paper. I asked Harry Schultz to see what he could figure out on the bases therein proposed, while I was still with U. S. Steel. The figures he gave me were so fantastic I never did use them—it looks as if U. S. Steel would have made more money out of safety than it ever did out of making and selling steel!

"And anyhow, the $2.00 for $1.00 in the *valid* statistics is convincing enough. I think, however, one can mention that safety education, which inculcates caution, thoughtfulness, orderly procedure, careful workmanship, and conservation of life must just naturally make better, more precise workmen, interested in the conservation of company property. And that's worth something! Then, too, there is its value as a wholly non-controversial avenue of approach for sound employer-employee relationships."

If these figures sound fantastic, and they are not, others may be examined which will prove the point further.

Shortly after July, 1940, a certain shipyard increased its attention to safety, employed full-time safety engineers and expanded the plant first aid facilities. In the short span of two years, the direct cost of compensation insurance was reduced by 35 per cent. Converted to dollars, this reduction amounts to approximately $14,000 per month based on current payrolls. If it may be admitted that the indirect costs are only double instead of four, five, or 10 times the direct cost, then the corporation is saving $42,000 each and every month through its accident prevention program. The cost of the present program does not exceed one-tenth of this amount. Another shipbuilding corporation is now conducting all California operations at 60 per cent of the direct insurance cost that would have been in order had not this corporation and its executives wisely invested in accident prevention during the past several years.

(*Continued on Page* 14)

Bearing Design and Failure

BY S. KYROPOULOS

IN THE broadest sense of the term, a bearing is any structural member of a machine that is so designed as to convert dry, wearing friction into wearless, fluid friction. The relative motion of the parts may involve a plain sliding motion (cross head, cylinder and piston) or an oscillatory motion (piston pin and bushing, spring shackle) or a rotating motion (crankshaft and connecting rod bearings). The member in which rotational or oscillatory motion is involved may be either a plain or sleeve bearing, or an anti-friction bearing. The purpose of this discussion is to consider some of the factors involved in the design of certain types of plain bearings.

Plain bearings consist of two units, the bearing proper, and the journal or axle. The bearing surface may be made of any one of a variety of materials, such as wood, plastics, cast iron, bronze, silver, alloys of lead, alloys of tin, etc. The alloys of lead or tin which are employed in bearings are commonly referred to as the soft bearing metals. The present discussion will be limited to this type of bearing material. Such a bearing usually consists of a highly rigid shell and a lining which is supposed to permit a certain amount of plastic flow and "embeddability" of dirt particles.

LUBRICATION

In order to convert dry friction to fluid friction, a lubricant is required for the proper operation of the bearing. The lubricant, preferably a moderately compressible and viscous fluid, supplies a complete fluid film between the journal and bearing. If some means could be provided to prevent the escape of the lubricant, any fluid, even air, probably would serve the purpose.

With regard to bearing performance, the principle of fluid lubrication is illustrated in *Fig. No. 1*. The bearing has a certain clearance with respect to the journal (greatly exaggerated in the sketch). On starting, the journal pumps the lubricant under itself and builds up a pressure which lifts the journal from the bearing. The escape of the lubricant is retarded by its viscosity. Higher viscosity, longer bearing, and smaller clearance act to decrease the escaping tendency. These variables are three of the factors to be considered in the design of bearings. With less lubricant escape the shaded peak shown in *Fig. No. 1* will be higher and the load capacity of the bearing will be increased. However, if the greater pressure is produced by higher viscosity, greater frictional heat may be developed which must be carried away by the journal, the bearing, and the flow of the lubricant.

It may be estimated from *Fig. No. 1* that the pressure established is far in excess of the feed pressure. It is obvious that the lubricant must not be fed into the area of high pressure from the lower pressure feed line, as this would decrease the pressure necessary for proper bearing operation. This presents another design factor which must be considered.

GROOVES AND DIMENSIONS

The dimensional characteristics of the bearing itself will play an important part in the operation of the bearing assembly. Oil grooves commonly employed in bearings present another factor to be considered in design. The effect of an oil groove placed in the high-pressure area of a bearing is shown in *Fig. No. 2*. The dashed curve indicates the pressure distribution when the groove is absent. The effect is to reduce the pressure to about that of the feed, and to prevent the unit from building up normal load capacity. On the other hand, some advantage may be derived from placing an oil distributory groove in the low-pressure area for a portion of the bearing length. Any grooving that crosses the high-pressure area is objectionable, except in those rare cases when fluid lubrication may be impossible under the particular operating conditions.

In general, circumferential oil grooves are objectionable, even though they may be the cheapest way of feed-

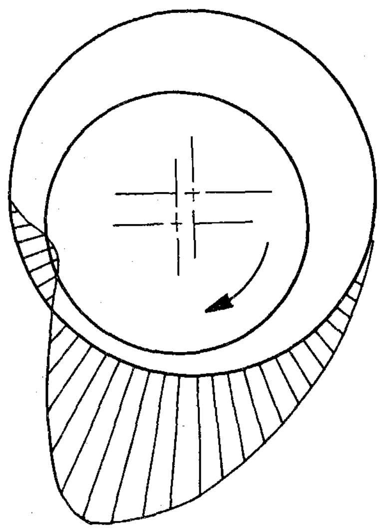


FIG. 1. Pressure distribution (shaded area) in lubricant film of plain bearing.

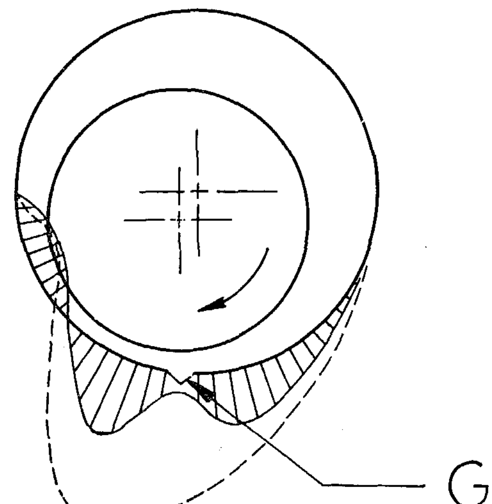


FIG. 2. Pressure distribution (shaded area) in lubricant film of plain bearing containing axial groove G.

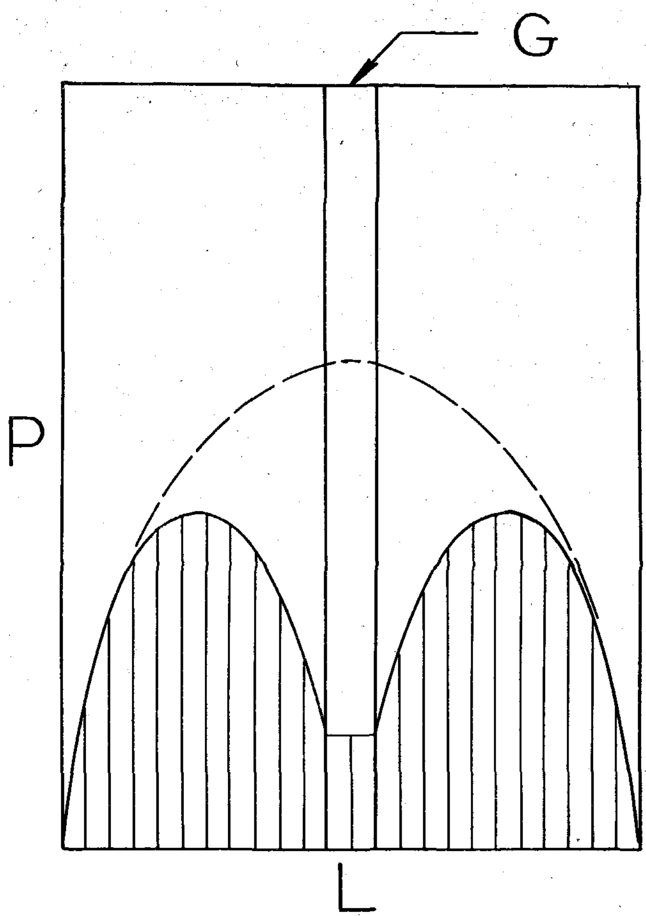


FIG. 3. Variation of oil film pressure *P* along the length *L* of a plain bearing due to its finite length. Pressure at ends equal to atmospheric pressure. Dashed curve outlines additional area without groove.

ing oil to the connecting rod bearings. *Fig. No. 3* illustrates the effect of such a groove on the pressure distribution along the length of a bearing. The dashed curve is the normal distribution, while the shaded area is the distribution which may be expected in the presence of the groove "G."

The basic factors in the design of a bearing are its dimensions and the oil viscosity. The dimensions refer to size, proportions, and clearance, which are usually the objects of compromise. The size and proportions may be dictated by available space and weight limitations, as in aircraft and automotive engines. The flexure of the shaft which passes through the bearing and the limits of accuracy in alignment are of great importance in modifying the ideal design. A misaligned journal leads to an axial pumping action. A small clearance is conducive to high load capacity, restricting oil escape, but it impairs oil flow and cooling as well as the beneficial damping effect of an otherwise thick oil film.

FACTORS LEADING TO FAILURE

Considering the factors of design and operation: What is a bearing failure and what is its course? Experience leads to the conclusion that the answer must be partly a result of speculation because the information is derived from postmortems and it is not possible to check all the factors which may have contributed to a particular failure. Discarding cases of gross neglect in operation and accidents, bearings fail by excessive wear and by fracture; both may be interconnected. A properly designed bearing with fluid lubrication should last forever, its whole projected area being hydrostatically loaded. Accidental or operational shocks are well damped by a thick oil film; surface asperities are small in comparison with the film thickness.

In case of accidental or occasional wear of the bearing surface or excessive temperature, or both, the clearance becomes greater or the oil becomes thinner and more oil escapes, thus decreasing the oil film thickness. Finally the oil film may become so thin that interlocking of the irregularities of the journal and bearing takes place, producing more wear and greater escape of oil and further deterioration of the bearing. Under these conditions any shocks or natural vibrations of the system are less damped and are taken up directly by a few points of contact. Under proper conditions these shocks are taken up by the hydrostatic pressure of the whole bearing. In the end the lining cracks, permitting pieces to fall out so that they become wedged between the moving parts, thus accelerating the destruction of the bearing. This is just one typical course of events.

In most cases of bearing failures inadequate or improper appraisal of operating conditions leads to inadequate bearing design, which in turn results in impaired lubrication and failure of the bearing. Thus, usually a bearing failure is ultimately a lubrication failure for which either design or operation or both are responsible.

While some failures occur because of failure of lubrication, this discussion will be concerned with the failure of reasonably well lubricated bearings. Referring to *Fig. No. 3,* if the designer computed the load capacity of the bearing on the basis of the ungrooved bearing and subsequently put in the groove, the bearing would be underdimensioned and shorter-lived. The effect is to replace the full-sized bearing with a twinned narrower one, with increased axial oil seepage. Great difficulties also are encountered in cases where the load on the bearing continuously changes its direction, as in connecting rod bearings, where the low-pressure area is not as large as in ordinary main bearings. Another source of difficulty lies in the flexure of journals and bearing shells. Such factors, combined with warranted or unwarranted compromises due to legitimate or illegitimate ignorance or neglect, are the main sources of bearing failures.

METALLURGICAL CONSIDERATIONS

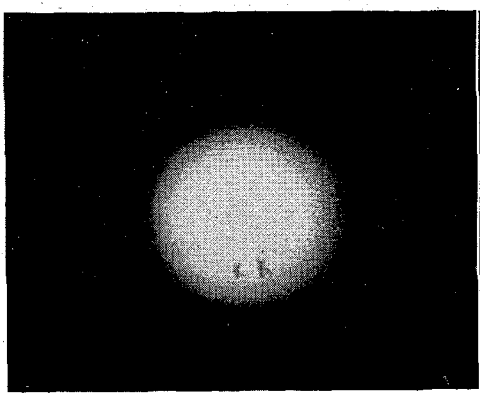
There is no similarity between a small bearing such as is used in an automotive engine and a bearing 15 x 15 inches in dimensions, when made of the same alloy.

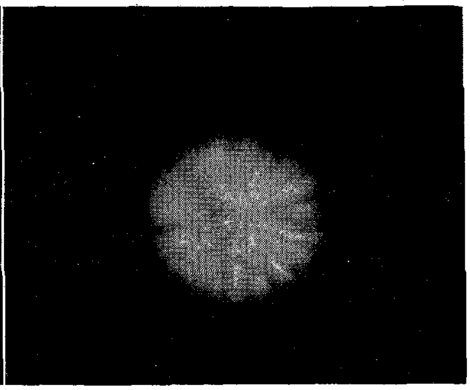
The conditions of solidification of the alloy which is poured in or onto the shell are different for the two cases because of the difference of the heat capacities of the shells. The grains in the alloy in the lining of the large bearing will be very much larger than those in the small bearing. Furthermore, the more or less inherently brittle intercrystalline substance is much more concentrated in the large bearing. There will also be a marked difference in the mixture ratio of the structural constituents in the two cases. Pouring and cooling conditions and workshop practice will produce marked differences in size and orientation of the grains in the alloy.

Consider the quality of the bond between the lining and the shell and the cooling of the lining with respect to internal stress. A smoothly machined bearing does not remain smooth at operating temperatures, because the structural constituents in the alloy do not expand uni-

FIG. 4. Reflection image of polished tin babbitt specimen at 25 degrees C., surface smooth (actual size).

FIG. 5. Reflection image of polished tin babbitt specimen at 150 degrees C., surface irregular from anisotropic thermal expansion of crystallites (actual size).





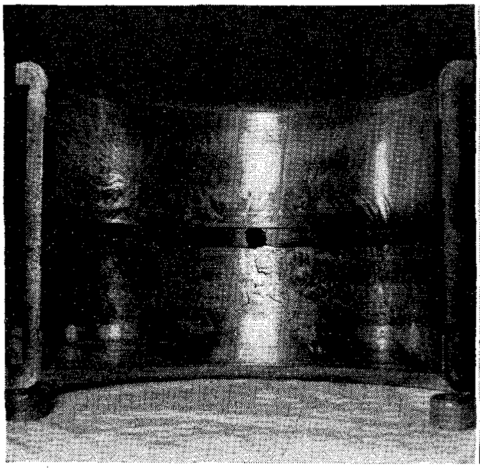
formly. As a matter of fact, the soft metals which practice considers indispensable for "matrices" of bearing alloys are those metals which have the highest thermal expansion. Thus, in the copper-lead alloy, widely used in Diesel and airplane engines, the lead expands almost twice as much as the copper and the shaft is supported solely by the soft lead and not by the copper under conditions of non-fluid lubrication. This is just the contrary of what the time-honored "bearing metal theory" maintains.

The constituents of the tin base alloys, the basis of "babbitt metals," are so anisotropic that the alloy composed of randomly oriented grains expands non-uniformly. Therefore, while the surface may be smooth at room temperature, it becomes quite irregular at higher temperatures because of the difference in expansion of the grains in different directions. This effect is illustrated in *Figs. No. 4 and 5* by the reflection images of a polished specimen of babbitt metal. The surface condition at room temperature is shown in *Fig. No. 4* and at 150 degrees C. in *Fig. No. 5.* The whole crystalline structure appears in bold relief on being heated and again becomes smooth when cooled to room temperature.

Recrystallization also plays a part in the performance of these materials. Letters were engraved into a babbitt metal specimen and then polished off until they entirely disappeared. Within a few days they reappeared because of recrystallization due to the cold working by engraving. The reappearance of the recrystallized area is shown in *Fig. No. 4.* This demonstrates the change in structure which may occur in these materials with cold work.

Not only may recrystallization occur, but also there may occur intercrystalline precipitation and diffusion. This takes place by virtue of the fact that as the alloy is cast it is not in a state of equilibrium. The precipitation and diffusion is the result of a tendency of the alloy to assume equilibrium conditions.

These changes in structure are more pronounced at operating temperatures which may double the rate for each 10-degree C. rise in temperature. *Fig. No 6* is a photograph of a large gas engine bearing of about 10 inches in diameter. It will be observed that a piece of the lining has fallen out and that several cracks appear on the surface of the bearing. The bright cloudy areas which take the shape of feathers and Arabian script and the cracks follow the grain boundaries of the alloy. The machining marks are barely visible in some areas between the bright clouds in the photograph. This condition is more clearly shown by visual examination of the bearing. The mechanism by which this appearance was produced may be outlined as follows: Under the shock loads to which the bearing was subjected the oil film became very thin; in time the high operating temperature facilitated the precipitation of the brittle compound *Sb-Sn* from the unstable *Sn-Sb* solid solution. The precipitate diffused to the grain boundaries and, because of its higher specific volume, formed raised ridges on which the shock loads were carried. The compound of which these ridges are composed is relatively brittle and thus with the shock loads, cracking is almost inevitable. With



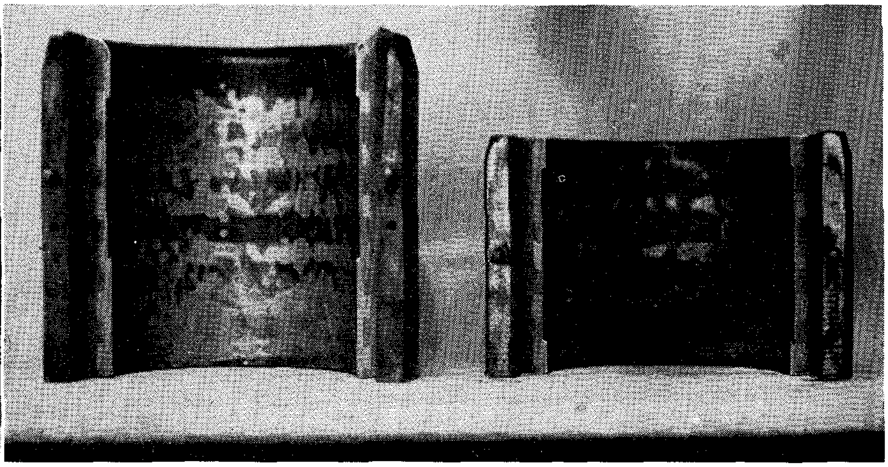


FIG. 6. Cracked bearing showing crystal structure due to intracrystalline precipitation and volume expansion.
FIG. 7. (Two views on right) Effect of dovetails on bearing performance due to greater expansion at dovetails (bright circumferential zones).

the load being carried on these protruding ridges, forming an area roughly 30 per cent of the intended area, the bearing was severely overloaded.

THERMAL EXPANSION

The non-uniform thermal expansion of the lining alloy may constitute an asset, even though the old concept of bearing operation would indicate otherwise. Under conditions in which an ideally smooth surface would only permit the maintenance of an extremely thin oil film, perhaps of molecular dimensions, a wavy and otherwise irregular surface may retain small pools of lubricant sufficient to maintain fluid lubrication to a greater extent. The duplex structure of a bearing alloy may constitute a safety factor rather than an indispensable requirement. In neglecting the benefits derived by non-uniform expansion the engine builder unwittingly sacrifices load carrying capacity. However, the different thermal expansion produces internal stresses within the lining which reduce fatigue life. It is therefore not surprising that modern aircraft engine bearings lined with pure silver have given excellent service, since they were designed with proper clearance and provided with a thin lead coating which lowers the occasional non-fluid friction. In this case the operating temperature is kept down and excessive growth of the lining which decreases clearance is prevented. An excess of growth would throttle down the oil flow, permit rise of temperature and eventual seizure of the shaft.

These phenomena are illustrated in *Fig. No. 7.* Here are two large compressor bearings in which the lining is anchored to the shell by circumferential dovetails. The lining is about twice as thick at the dovetails as at other places. It is clearly impossible to maintain proper clearance in the bearing unless the operating temperature corresponds to that at which the bearing was machined. In operation the temperature was higher and therefore the lining bulged at the dovetails to such an extent that the clearance between journal and bearing was decreased in these circumferential areas. Eventually there was space for only a very thin oil film which carried the whole load, while the spaces between the dovetails acted as wide shallow circumferential grooves. In this case actual seizure of the shaft and outright melting of the babbitt did not occur, because of the plastic flow of the babbitt and comparatively favorable operating conditions.

PRINCIPLES FOR DEVELOPMENT

Once the chain of events has been recognized—duplex structure (or anisotropic metal), uneven expansion, reduced area, overloading, cracking—the inherent limitations of the current bearing alloys become evident and the principles for a rational development of bearing alloys toward longer service appear clear. These principles, the outcome of research at the California Institute of Technology, involve the field of physicochemical analysis in engineering, analogous to previous physicochemical analysis of lubrication.

Accident Prevention

(Continued from Page 10)

MANPOWER CONSERVATION

In connection with safety prevention, and keeping the man on the job, recognition of manpower figures which indicate present-day demands are worth reviewing. This information could not be given by any better authority than that of Lawrence A. Appley, executive director of the War Manpower Commission. In the September issue of *Engineering and Science Monthly* he stated that "There are 22,000,000 men between the ages of 18 and 37 inclusive registered by Selective Service Boards. This includes all men regardless of physical, military, or occupational status. Approximately 14,000,000 of these men can meet the physical requirements for military service.

"The armed forces will require 10,800,000 of this 14,000,000 by the end of 1943. That leaves us a balance of *3,200,000. Of this number 1,500,000 will be de*ferred for agriculture.

"By simple arithmetic we now have 1,700,000 left for non-agricultural deferment. While that is more than are now occupationally deferred it must be realized that there are many men who have been deferred for dependency who, if they were not so deferred, would be for occupation.

"Before we jump to the conclusion that there are a possible 1,700,000 deferments of able-bodied men for non-agricultural occupations, we must realize that none of the above figures provides for any replacement which will be needed to maintain the armed forces at 10,800,-000. That need will be determined by the human cost of the military campaigns that are ahead of us. Neither do they provide for personal hardship cases.

"This manpower arithmetic is another one of the 'dynamic factors' which influence the handling of the manpower problem."

In view of these figures one may ask, "What is industry doing to conserve and preserve manpower in this time of direct need?" It appears that not enough is being done in this direction. One of the most destructive attacks made on this nation last year was not made by a foreign enemy but by accidents. These accidents left 93,000 dead, 350,000 permanently disabled, 9,000,000 lesser casualties, and 450.000,000 man days of lost production. Putting it in a different way, the national economic loss was $5,200,000,000. It cost as many productive man days as would be required to build 72 battleships. All this destruction, this delay, this waste of manpower and materials was caused by accidents. Even though we recognize the seriousness of these figures, accidents are increasing. *Accidental industrial deaths increased five* per cent in 1942 over 1941. Approximately 200,000 more accidental injuries occurred last year than during the preceding year. There was a rise of 10 per cent in the number of man days lost to industry. In 12 states, deaths from occupational accidents showed increases ranging from 25 to 77 per cent.

With millions of employees being shifted into strange new jobs, with other millions of new untrained workers being drawn into plants, working under terrific pressure and at top speed, and with the strains of dislocations of wartime conditions multiplying hazards to life and property throughout the country, the accident toll will continue to increase, and certainly will not decrease until adequate preventive measures are taken.

The fact that off-the-job accidents far exceed the number and severity of occupational accidents must not be overlooked. It might be concluded that industry cannot control or influence off-the-job accidents in view of these figures, but such is not the case, for plants which have reduced work accidents have at the same time greatly reduced off-the-job accidents among their employees. This fact tends to substantiate the claim that accident prevention is mainly accomplished through education, training, and executive order. Therefore, one must accept the axiom that safety is a responsibility of management.

If really good practice in the elimination of preventable accidents is to be reached and held in any establishment, the top management must accept full and definite responsibility and must apply a good share of its attention to the task, just as it does to any other undertaking of vital importance. Every kind of work that men do involves some degree of hazard, and every uncontrolled hazard, if given enough time, will produce its share of injuries. But proper attention to safety will result in the elimination of almost all the injuries that would otherwise occur, regardless of the industry, the type of operation, or the occupation in question. In management is vested all authority, the determination of policies and executive direction; from management must come the drive for safety. Management must want to eliminate injuries badly enough to make accident prevention a vital part of all activities. Prevention must be given continuous attention along with such matters as cost, quality, and production.

Perhaps in time of peace you may treat with accidents as you please, particularly if you are willing to pay the bill. But in time of war, it is your patriotic duty to conserve the only resource for which no substitute can be found—the number one raw material of war—MAN-POWER.

Modern Construction in Turkey

(*Continued from Page* 4)

and supplies, asphaltic membranes and hardware (with the exception of nails) are imported from foreign countries.

Labor is cheap compared to material cost. Unskilled labor is abundant and the wages are low. A pick-and-shovel workman, for example, normally earns 60 to 90 cents for an eight-hour day. Of course, one should consider that it is possible for this type of a workman to feed himself for 40 cents a day, but even then his financial life is very modest. Skilled labor is somewhat better off; a carpenter earns from two to four dollars a day. The big jump comes in the earnings of the professional class, such as the engineers and architects. This is primarily due to the great need for such services, and the civil engineer or architect enjoys a distinct position in income and prestige. Strikes and labor disputes of major proportions are practically nonexistent in Turkey. Problems that arise between the workmen and the employer are referred to the "labor inspectors," who see to it that such problems are settled according to the laws and regulations of the republic.

As a result of low labor rates the cost of construction in Turkey is below what it is in the United States. Apartment houses cost from two to three dollars per square foot and the very modern public buildings that are being erected feverishly at the present time cost from four to eight dollars per square foot. The labor cost in the big items such as reinforced concrete, brick masonry, plaster, etc., is about 15 per cent of the material cost. The contractors are naturally very sensitive about any kind of material waste.

Bids for government construction follow a method which has proved successful in this period of intensified construction. The architectural plans are prepared by government offices and a rough material estimate of the future building is made. Then the job is let out for bids. Each bidder receives a set of design, material and workmanship specifications, along with the general architectural drawings. The designing offices of the participating contractors use their own judgment and skill in producing the structural design. The contractors each submit a bid which is based on unit prices. These unit prices when multiplied by the material quantities add up to the total price of the bid. The advantage of this method is that it stimulates the contractors to prepare a design that will be of minimum total cost. As a result of this system the contractors are very conscious of the value of a skillful structural engineer.

LESS LABOR-SAVING EQUIPMENT

Labor-saving mechanical equipment for construction is not used as much as in this country. Concrete mixers and material elevators are usually the only mechanical equipment used in the field. Vibrators, for example, are not used, because it is cheaper to tamp the fresh concrete by hand tools, and the forms are not built sturdily enough to withstand the vibration. Two-inch boards are used under beams and one-inch planks are used for slabs and for sides of beams. All attachment of forms is done by nails.

The building code for reinforced concrete calls for all bars to be provided with hooks. Since plain bars are used exclusively and earthquake forces are expected, this is an inexpensive security measure. As in most European codes the value of shear strength of concrete is neglected once the shear intensity exceeds 40 pounds per square inch. The allowable fiber stresses in concrete are about 25 per cent lower than the values generally used in the United States for ordinary construction. Up to recent years moment factors were used, or, for more exact analysis, the "three-moment equation"; however, the Hardy Cross method of determining moments is becoming more and more popular at the present.

Due to the great demand for technically trained men the government has adopted a very benevolent attitude in employing foreign engineers and architects, and most of these men have done splendid jobs. The foreign engineer, however, has a few problems to consider before making his luxurious salary. The tax rate starts at about 30 per cent withholding and increases as the income gets larger. When leaving the country a person is allowed to take out only one-third of the cash he has made. However, judging by the fact that there are a large number of foreign engineers in the country, these restrictions apparently are not too severe.

The photographs displayed with this article were taken in 1939, and show features of design and construction of the Graduate School of History, Language and Geography, located at Ankara. The author worked on the structural design of this project and was present during the entire period of construction.

Alkylation Plant

(*Continued from Page* 8)

review might be 45 feet long, eight feet high, with possibly three horizontal tiers of dials of various sizes and shapes. At any moment a glance will show what any unit of the equipment, provided with an instrument connection, is doing.

Electric power and light installations in an alkylation plant are extensive. Explosion-proof motors are used in all areas considered hazardous because of the possible presence of hydrocarbon vapors. They might vary in size from ¼ horsepower for driving an exhaust fan to 450 horsepower for furnishing the motive power for a large water pump, synchronous motors being preferred for such units. Electric current is usually brought in several appropriate voltages to a main switchroom, from which it is distributed through panel boards to its many purposes. Good lighting must be provided for all equipment, and to the top of even the tallest bubble column. Many of the instruments contain electric devices. In many plants a turbogenerator is installed to start automatically in case of power failure and to maintain at least the minimum light throughout the plant necessary for operation. The instruments are also connected to this emergency power supply.

BUILDINGS

In California it has been found entirely satisfactory to have most equipment, including pumps, in the open. In more inclement climates, however, housing requires a considerable outlay, particularly when the atmospheric temperature hovers below zero for months and is accompanied by heavy snowfalls. Steel frame, corrugated iron covered buildings serve in many locations. For colder regions, reinforced concrete frames with brick walls are often used.

Unit steam heaters or radiators are provided to maintain temperatures in the buildings safely above freezing, and exhaust fans are installed in the walls a short distance above the floor to remove hydrocarbon vapors, all of which are heavier than air. Steel windows and doors are preferred for such substantial buildings. The pipelines of many sizes and purposes are supported from the beams of the floor above, and others are brought to the pumps in trenches, sunk below the floor, covered with steel plates or gratings and connected to the sewer.

Compressed air must be available for instruments, dried in special vessels, when the climate is such that moist air might freeze in small air lines, for the blowing of sulphuric acid from vessel to vessel and for other purposes. Air compressors with accumulators must therefore be provided.

Heavy and tall structural steel supports are needed for certain portions of the refrigeration equipment, for the contactors, and for the reactors in the isomerization plant. All bubble towers must be made accessible throughout their height by means of steel ladders and platforms. Operating walkways over some of the horizontal vessels add to the use of structural steel.

In order to conserve heat and to better maintain the necessary operating temperatures, many bubble columns, heaters, turbines, pipelines and other units of the equipment are insulated. Cold insulation is required on all equipment operating at lower than atmospheric temperature.

COOPERATION

It should be pointed out that no two plants of the same size will require identical equipment. The exact composition and purity of the charging stocks determine the operating cycle and equipment. The type of foundation, the type of building construction, the type of power source to be employed will depend upon the local conditions prevailing at the plant site.

The construction and the assembly of the equipment for a plant to accomplish these operations is a challenging undertaking. Laying the plans and putting them into operation requires the cooperative effort of chemical, mechanical, civil, electrical, construction and metallurgical engineers, as well as purchasing personnel. This is typical of an extensive engineering job involving diversified activities.

C. I. T. NEWS

IN PRAISE OF TRUSTEES

By ROBERT A. MILLIKAN

On January 24 a dinner was held at the California Club to honor James R. Page, recently elected President of the Board of Trustees of the California Institute of Techonology. Dr. Millikan's remarks at that dinner are presented here because it is believed that the readers of ENGINEERING AND SCIENCE will be interested in the part a Board of Trustees is playing in the operation of one type of war industry.—Editor.

YOUR HOSTS are the Trustees and I am sure you want to know what manner of job they do. Being very modest men they will not tell you, but I have insisted on being given a few minutes to do so, for I am not on the Board and I can properly speak "In Praise of the Trustees."

The fact that they have always maintained the policy that no salaried employee can be a board member, or indeed have a vote on its finance committee, reveals in itself the seriousness and the long-range wisdom with which they take their job in the rendering of a wholly free public service to the community and the nation.

Let me first say something in general about the genus "Board of Trustees," for our higher educational system in the United States consists of much more than a thousand of these privately supported colleges and universities all over this land created wholly by private initiative and controlled entirely by Boards of Trustees operating under charters granted by 48 states. Here is the free democratic American way of life at its best—free from all possibility of political influences. It is the finest expression of the free-enterprise system here consisting in the self-education of each community in the finding and meeting of its own educational needs, the most fundamental of its needs. Add to these private institutions the much smaller number of our tax-supported institutions created by the communities of 48 different states—it is in the number of these states that freedom's safety lies—and there has still been maintained the principle of local self-government in our higher educational system. This is the cornerstone of the freedom which we are fighting this great war to preserve.

With any centralized system of education such as is characteristic of all totalitarian states, it is inevitable, as the recent history of the world amply demonstrates, that education becomes replaced by indoctrination in the interests of the perpetuation of the power of the group in control of government, and freedom is destroyed at its source.

These Boards of Trustees are, then, the most potent guardians of the liberties of the American people. No higher praise than that can be accorded to any group. The greatest menace to the future of the United States is just now the terrific pressure for the encroachment of the federal government upon our educational system. According to the founding fathers and the teachings of history, the federal government exists, and should exist, primarily for defense against external aggression.

I hope that what I have said so far is sufficient to scotch the idea that the men chosen to sit on Boards of Trustees are chosen primarily because they have had long and successful training and experience as community pickpockets.

To further illustrate the responsibilities of Trustees in general, let me give you the definition of the functions of our American system of higher education. It has a two-fold function, first, to pass on to the coming generation the torch of the accumulated knowledge and understanding of the past, and second, to increase the store of knowledge to be thus transmitted. Higher educational institutions are by definition, then, teaching and research institutions. They divide their activities between these two functions differently, as they may well do.

Now, turn to the answers to the question, what is this particular Board and what does it in particular do? It consists of 19 men, viz., President Page and Vice-Presidents Macbeth, Cravens, and Harvey Mudd, and the following members: Harry Chandler, Harry Bauer, Ben Meyer, W. L. Honnold, George Farrand, William McDuffie, P. G. Winnett, John O'Melveny, Albert Ruddock, George Grant Hoag, Ralph Lloyd, Reese Taylor, Robert Gross, Norman Chandler, and Keith Spalding.

On account of the present national emergency, the responsibilities that are now upon these men have increased enormously, making unusually large demands upon their business acumen and financial and administrative experience and skill. The research activities of C.I.T. are now largely concentrated on war projects assigned to it by the military arms of the U. S. government. These assignments are made through about 50 war contracts involving many millions of dollars which have required the appointment of a special contracts committee consisting of Alexander B. Macbeth, John O'Melveny, and Reese Taylor—a committee which meets often, studies the contracts, negotiates changes when it disapproves their form, and finally recommends them for action by the Board, which in this emergency is meeting the first Monday in each month.

The carrying out of these contracts has involved an enormous expansion of the personnel of the Institute, its paid employees numbering now 3400, not counting any of its 1200 students. Its work is now being carried on on 14 different campuses, without counting any of the 180 Los Angeles industrial concerns to which it has let subcontracts. These campuses are, first, its central campus on California Street between Wilson and Hill Streets, where the Trustees have a seven million dollar plant to conserve; second, the Palomar campus involving an investment of nearly the same magnitude; third, the Kerckhoff Marine Biological Laboratory at Corona del Mar, where Dr. Morgan has done much of his work in recent years and where primitive forms of life are found in abundance; fourth, the Seismological Laboratory near the Annandale Golf Club, a part of the Balch Graduate School of the Geological Sciences, and a most active and fruitful center of our growing and useful knowledge of earthquakes and the interior structure of the earth; fifth, the Kerckhoff Genetics farm at Arcadia, where the genetics of, and improvements in corn are now under intensive attack, with the aid of all the knowledge of genetics developed in the Kerckhoff Laboratories on the main campus.

The next five campuses are war campuses involving many hundreds of workers and between one and two hundred new temporary buildings, mostly of wood. Two of these are out in the desert and three are in canyons in the surrounding mountains.

Three more war campuses are inside the limits of Pasadena but off the main campus, and represent new temporary testing and inspection laboratories, machine shops, and transportation facilities which take care of the flow of material in and out between C.I.T., their ultimate destination, and the 180 Los Angeles subcontracting businesses that supply parts.

The fourteenth and last of these campuses is the two and a quarter million dollar so-called cooperative wind tunnel near the Pasadena light and power plant which will be in operation in a very few months. It will be the first wind tunnel in the United States capable of testing the performance of airplanes for speed ranges of from 400 to 750 miles per hour, which latter figure is the speed of sound.

That is the kind of a job these Trustees are now handling. It will give you some idea of what the plant protection committee, consisting of Trustees Macbeth, Ruddock, and Cravens, has had to do this last year; of the responsibility which the finance committee, meeting every two or three weeks and consisting of Trustees Page, Mudd, Meyer, Bauer, and Macbeth has on its shoulders; these committees, plus the contracts committee consisting of Trustees Macbeth, O'Melveny, and Taylor, report directly to the Board. The Institute has no president but its normal work of supervision of the whole is done by the Executive Council consisting of eight: Trustees Page, Mudd, McDuffie, and Macbeth, and Faculty Members Munro, Mason, Tolman, and Millikan, plus Comptroller Barrett. These Trustees have just elected as captain of the whole enterprise a man who has spent for years, as have most of the Trustees, an immense amount of time running errands as the right sort of a Page is supposed to do, not merely for C.I.T. but for the War Chest, the Community Chest, the Automobile Club, the All-Year Club, the religious organizations of the city, and I don't know how many other Los Angeles activities that require brains, judgment, business experience, and devotion to community-development enterprises.

CALTECH PROFESSOR NAMED TO STATE PERSONNEL BOARD

Governor Earl Warren announced early in April the appointment of Robert D. Gray, professor of economics and industrial relations at the California Institute of Technology, to be a member of the State Personnel Board. Professor Gray succeeds John J. Hamlyn for a term ending January 15, 1943.

Professor Gray came to Caltech three years ago to take charge of the industrial relations section at the Institute which was organized to aid in the gradual improvement of relations between employers and employees. A native of Warren, Pennsylvania, he was graduated from the University of Pennsylvania in 1930 and continued part-time graduate work and research work at the university until 1936. He then held the post of assistant professor of economics at the University of Connecticut.

The Nation's Achievements During Two Years of War

in research, production and fighting

By REAR ADMIRAL WILSON BROWN*, U.S.N.,
Naval Aide to the President of the United States

EVEN in ordinary times most of us find graduation to be a pretty exciting experience; but to graduate, as you gentlemen are doing, in the midst of the most devastating war the world has ever seen, plunges you into unlimited opportunities for accomplishment, adventure, and service to the human race. To many of you the far horizons of today will soon become familiar ground; strange lands and strange people will play vital parts in your lives; undertakings, which today are wholly unknown to you, may soon become commonplace. The primeval struggle for existence on which you will embark will not always be pretty; but it will be real and vital and exciting; and it will make heavy demands on all of your best qualities—courage, adaptability, perseverance, ingenuity, honesty, and loyalty. . . . .

I think we may accept as a truism the statement we hear on all sides—that the world struggle is on such a vast scale that no one—literally no one person—can visualize all of it. We can study charts and statistics and comparative figures from which we can make plans and predict results with a certain degree of confidence. We may even see for ourselves huge fleets of ships; a steady stream of aircraft passing overhead for hours at a time; armies of such size that days and weeks are required to pass through a given port; supplies and munitions overflowing all available storehouses and piled in dumps that stretch for miles along the road. It is another question, however, to visualize fully all of the people and forces and figures that we have to deal with and to understand the multitudinous readjustments that must be made in the mechanics of world society to enable such enormous forces to operate. Armies of many millions; air forces and merchant ships in such huge numbers that only two years ago our enemies scoffed at our then goals as fantastic; navies doubling and redoubling in size in less time than formerly was required to build a single ship; trucks, tanks, guns, and supplies of all kinds rolling out in overwhelming numbers and pouring to the scene of battle with a force and power that will not be denied. . . . .

I have been freer to move about than most of you, and I shall try to tell you of some of the accomplishments that I have seen outside the country.

In the early months of the war I was in command of a Carrier Task Force in the South Pacific. We were the first United States Naval Force to reach the Coral Sea. Like the whalers of old, we cruised about for nearly 60 days without ever coming to anchor or sighting a port. All of our fueling and transfer of stores was accomplished well out of sight of land with a weather-eye open for enemy submarine attack. We kept out of sight in the hope of catching a portion of the Japanese Fleet by surprise away from the coverage of his landbased planes; but we also stayed continuously at sea for the very simple reason that there was not a single harbor west of Pearl Harbor where our deepest draft vessel could anchor with security against enemy submarines and without undue risk of piling up on a pinnacle rock. As it was, we had to navigate waters that had not been surveyed for 150 years. At times our aircraft had to scout ahead to warn us of uncharted shoal water. Now, less than 18 months later, we have a complete chain of strongly defended bases with many good harbors stretching from California to Australia. From these firmly established bases, our forces have made fine progress in launching the relentless closing-in on Japanese aggression. In the short period of 18 months harbors have been surveyed; defense forces have been made secure; supply bases set up; airfields placed in operation; barracks, hospitals, movies and recreational facilities have followed the flag. We now have some of the bases from which huge air forces and naval forces and armies may press home our victory. A large area of the world has been developed in a few months to an extent that in times of peace might not have occurred for centuries. Veritable miracles have been accomplished by the complete release of all of the energies of the most powerful, the most energetic and the most resourceful nation of the world.

We all know what critical sea, air and land battles have been fought in order to win for us this secure foothold in the Pacific. We can all visualize what battles still lie ahead before our enemy has been reduced to impotence and we have evened the score for his treachery and barbarity. May we never again allow a possible enemy alien within 100 miles of the island bases we may select as our strong points and outposts.

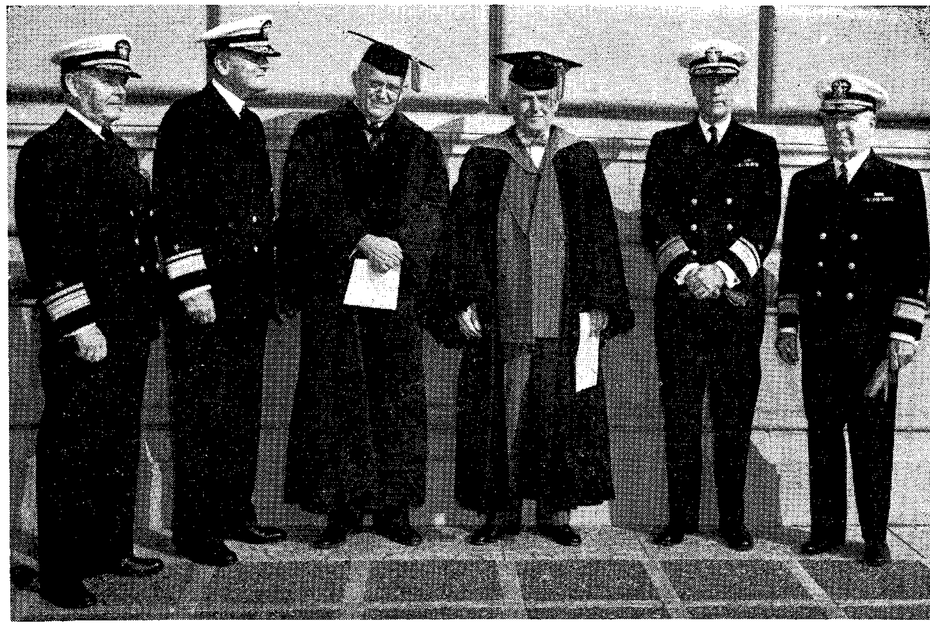
. . . . . Within the past few months I have been privileged to visit the Mediterranean, the Persian Gulf area and various parts of the Middle East and Africa. I wish you all could see for yourselves what your fellow soldiers, sailors and airmen have done in preparation for the assault on the citadel of Europe. At every harbor of any size, a United States Port Authority is established with all of the equipment required for the service and supply of the United States Navy, United States transports, and United States cargo ships. At every port we were met by our Army and Navy officials. We went ashore in American launches, were driven to our destination in United States cars with United States drivers; our baggage for a considerable party was distributed with an accuracy and promptness that might be copied by some of our bigger transfer companies. We found our service men completely at home in their new environments in strange lands among strange people; eager to help the new arrival and quite ready to patronize him for arriving so late. Similarly, our chain of air bases literally encircles the globe. Wherever needed, airfields have been carved out of the wilderness, or out of the desert, or out of the jungle in spite of all physical obstacles. Whether in the tropics or in the Arctic, all of our airfields might have been turned out by the same hand; all have well-built runways and landing areas; sufficient fighters to defend the base; repair and storage facilities; reasonably comfortable barracks; laundries; movies, except at the very front; American uniforms and frank though serious American faces; and the Stars and Stripes flies from the flagstaff. Here, too, the new arrival is made welcome with careful attention to his welfare and comfort and future employment.

Armies by the millions; aircraft by the thousands; huge convoy after huge convoy of deeply-laden ships are pouring into the harbors and airports of Europe for the undoing of our enemies and for the aid and comfort of our Allies. . . . .

*An address delivered at the Commencement exercises of the California Institute of Technology February 18, 1944.

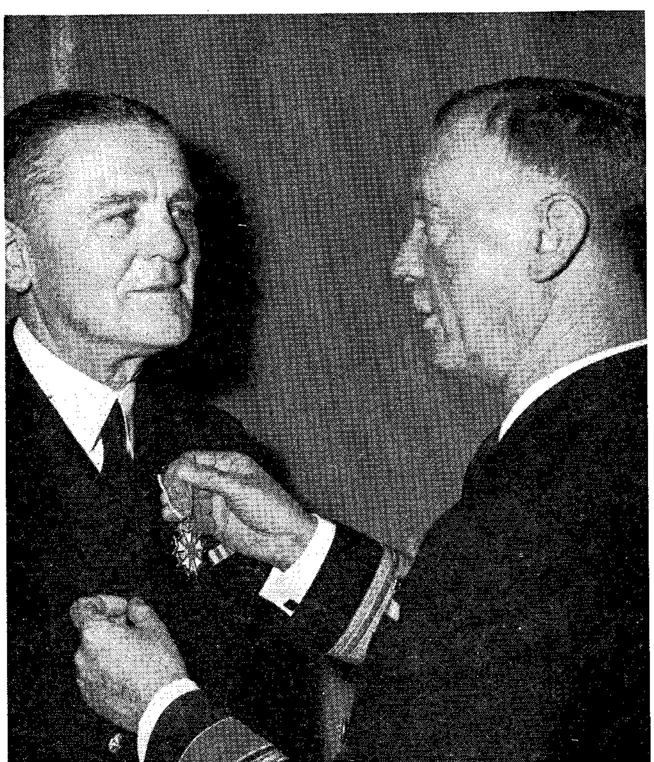
AT RIGHT:

Left to right: Rear Admiral I. C. Johnson, Head of Officer Procurement, 11th Naval District; Rear Admiral Ralston S. Holmes, Navy Department Liaison Officer, N.D.R.C., C.I.T.; Reverend Lloyd Douglas, Commencement Chaplain and author of "The Robe"; Dr. Robert A. Millikan, Chairman of the Executive Council, C.I.T.; Rear Admiral Wilson Brown, Naval Aide to the President of the United States, Commencement Speaker; Rear Admiral J. R. Defrees, Inspector of Naval Material, Los Angeles District.



Indeed, in addition to being the arsenal of democracy as we promised, our Armed Forces have built up a war machine more powerful in the aggregate than any other nation's in the world and our fighters are proving their superiority over our enemies in every field of combat. Our weapons and our fighters are of the best. America is on the march! We have accomplished in two short years more than our enemies have done in 25 years of deliberate, planned treachery. . . . .

. . . . . your generation will have to decide what must be held on to and what changes, if any, must be made to meet changing conditions. The postwar period will require many major readjustments. We will pass through another phase of trial and error. New theories of government and finance will be shouted from the housetops. Old abandoned theories will be dressed up with new trimmings and new allure. The millennium will be promised by factions whose true aims may be as different as the poles. It will be hard to know what to believe and what not to believe. You will have to keep your heads and have faith that destiny and the native commonsense of our people and the ever increasing benefits of education will pull us through again as they have so often in the past.



Rear Admiral Ralston S. Holmes receiving Legion of Merit Award from Rear Admiral Wilson Brown, Naval Aide to the President, and author of the accompanying article.

I do not pretend to know why this nation has been able to do what it has done. We must agree, of course, that we have the very great benefits of material resources and favorable climate. Our founders and forebears brought with them from Europe their heritage of hope, aspiration and experience that derived from generation after generation of masses of humanity struggling for a better world. And yet, people with fine ideals have migrated to other portions of the globe without making material progress to be compared with ours. Something in our heritage gives us a deep-seated national sense of fair-play and a very real wish to help other people that inspires trust and hope and confidence among our own people and, also, among most of the other peoples of the world. My own faith in our greatness is based upon the conviction that our Constitution is an inspired document. It has served us well. I believe we must preserve its basic merits and not be in too great a hurry to throw overboard the well-tried for promising, but untried, theories. Under the shelter of the Constitution we have developed schools and colleges in such numbers and of such quality that our youth are able to take full advantage of the opportunities offered for initiative and enterprise. It is our system of education that enables our people to learn quickly the arts of modern war just as they master the arts of peace. During each succeeding generation it becomes more and more apparent how the spread of education adds to our ability to do things. When I entered the Navy 45 years ago, many of our enlisted men could not read. Everything had to be taught laboriously in oral classes. Today all of our men can learn a great deal about any technical subject with the sole aid of properly prepared books of instruction. That is certainly one of the reasons why we can learn so quickly and accomplish so much in such a short time.

The world has known for many centuries that men cannot hope to defeat an armed foe with bare hands. It has also been recognized for centuries that antiquated weapons are pretty helpless before their modern successors. During this war, however, new weapons have developed so rapidly that one of the basic struggles has been to keep ahead of the enemy in research and development as well as to keep ahead in quantity and quality of arms and men. Fortunately for our survival and for the survival of our faith and customs and manner of living, we have never been content merely to copy weapons and methods from others. We have always done our full share in invention and development. Today, however, thanks again to our colleges and to the large number of eager, energetic, young scientists, we have set a new record that is doing so much to shorten and to win the war. Many of our war inventions will be of inestimable value to civilization in peace. All research being marked "Secret and Confidential," you have probably been greatly mystified by the mysterious comings and goings of the members of your own Research Department. I am, of course, not at liberty to disclose any secrets; but I can reveal to you what you all probably already know, that when the history of war inventions is written, the name of California Institute of Technology will stand high on the Roll of Honor. As one who has been privileged to see for himself some of the early work of your scientists, and also to follow ever since with deepest interest the use to which your inventions have been put, I tender my homage to the vision, leadership, knowledge, and sustained effort that have done so much to provide our fighting forces with some of their very best weapons. The country will hail your accomplishments when the veil of secrecy is lifted.

When we attempt to evaluate the factors that will lead to victory, we are, perhaps, apt to overrate material resources, war production capacity and total population; and to lose sight of the even greater importance of the fighting qualities of the race. There can be no question that the number of planes, ships, guns and all of the other instruments of war that we are pouring out in such vast quantities are playing, and will continue to play, a decisive part. But our greatest strength lies in the fact that we are head and shoulders above all other nations in the vast number of young people whose basic education enables them to master every technical detail of modern, scientific war and who, in addition, have the will to fight and the will to win. Our colleges throughout the nation have transformed themselves into huge training centers for our armies and navies. Other countries have some extremely intelligent, well-educated people; but among the nations at war the production of educated, fighting men and women is far below ours.

It would be fooling ourselves to suppose for an instant that you gentlemen will become competent, well-rounded officers overnight; but I say to you with all earnestness that each and every one of you can master some phase or specialty of the profession of war in a very short period of time so as to make each one of you a highly useful member of the service. College men who joined the services only a few months ago are already experienced veterans, living up fully to all of their obligations and making us all thrill with pride in their accomplishments. What they have done you can do. You have every right to approach your new duties with confidence. However, in order to lead, and in order to command the respect of your subordinates, you must master thoroughly every detail of the particular duty to which you may be assigned. You must learn quickly more about your own job than anybody who looks to you for orders. You can do this by virtue of your previous education and training; and by the continuance of the energy and industry that has brought you to your present position. You must strike at the heart of whatever duty may be assigned you, to learn the essentials and to apply what you learn to increase the fighting efficiency of your unit. Do not allow yourselves to be confused by "red tape" or by tradition, which appears to divert you from essentials to matters of form that impede progress. Traditions and ceremony have their value and importance in time of peace. In time of war nothing must obstruct offensive and decisive action. We must always do the commonsense thing in the most direct manner possible. We must keep in mind the importance of the time element in everything that lies ahead of us. We must hasten our mobilization, our education in war, the part each one must play in our war machinery. The success of a battle, to say nothing of self-preservation, requires that reaction to emergency shall be correct, precise and immediate. It is, therefore, of paramount importance that you train yourselves and your subordinates to preserve constant alertness and immediate readiness for offensive action. War in the air, on the sea and on the land still requires the same cool nerve as was required for the winning of the west. You have got to draw first and shoot straighter than the other fellow. Our score to date shows that we can still do it. I wish you good luck, good hunting, and happy landings.

COMMENCEMENT EXERCISES

THE commencement exercises closing the Institute academic year 1943-44 were held at 4:00 P.M. on Friday, February 18, at the Civic Auditorium in Pasadena. The season and the setting were quite different from those with which previous graduating classes have been familiar. The candidates for degrees entered the auditorium to martial music provided by the Navy V-12 band. The candidates were followed as usual by the faculty, trustees, and special guests who took their places on the stage. Besides those participating in the exercises, the guests included Rear Admirals I. C. Johnson and Joseph R. Defrees.

The invocation and chaplain's address were given by the Reverend Lloyd C. Douglas, author of "The Robe." The principal address was presented by Rear Admiral Wilson Brown, U.S.N., Naval Aide to the President. His subject was "The Nation's Achievements During Two Years of War in Research," (see page 18).

Following Admiral Brown's address 10 certificates were awarded for the completion of the Navy Engineering Specialists requirements. The Bachelor of Science degree was conferred upon 94 men, 13 men received the M.S. degree, and nine men received the Ph.D. degree.

Dr. Millikan presented "The Progress of the Institute" starting with its founding in 1891 by Amos Throop and carrying through its development to the present. He extrapolated the curve of the Institute's development into the future, proclaiming that the Institute would be helpful in meeting the problems which will be associated with the industrial advancement of the Pacific Coast area.

CALTECH FRESHMAN ADMISSION DATES REVISED

THE Institute faculty, at its March meeting, approved a revision of freshman admission schedules which will henceforth permit entrance of new students at the beginning of each semester. Since the present accelerated program of instruction calls for three semesters a year, a new group of freshmen will be admitted every July 1, November 1, and March 1. As in the past, admission will be based on the results of competitive examinations plus the candidates' high school records.

In announcing this change, Dean L. W. Jones, Institute Registrar, called attention to the schedule of dates involved in the next two admission periods:

FOR ADMISSION JULY 1, 1944

Applications must be received by the Registrar by April 24, 1944.

Examinations will be held May 6 and 13, 1944.

Notice of acceptance or rejection will be mailed by June 7, 1944.

FOR ADMISSION NOVEMBER 1, 1944

Applications must be received by the Registrar by August 1, 1944.

Examinations will be held September 9 and 16, 1944.

Notice of acceptance or rejection will be mailed by October 7, 1944.

A limited number of scholarships will be awarded to entering freshmen each semester. These are awarded on a competitive basis to the most promising students admitted to the Institute, as judged by all information available, without reference to financial need. Such scholarships carry full or half tuition, depending upon individual circumstances. In addition, half-tuition grants are awarded to other students of superior ability who otherwise might be prevented from attending the Institute.

SPRING SPORTS

By HAROLD Z. MUSSELMAN*

THE six colleges and universities in the Los Angeles area who are carrying on an intercollegiate sports program have drawn up a schedule of spring sports with each other. Five of these schools, U.S.C., U.C.L.A., Occidental, Redlands, and Caltech, are Navy V-12 schools and will be represented by strong teams in all sports. Pepperdine, with only a civilian enrollment, expects to be represented in most sports.

All schools will meet each other in home and home baseball games, while all but Pepperdine have a complete track schedule. Schedules in tennis, golf and swimming have not been completed, but the date for championship events has been named.

Caltech has only three home track meets this year, but all of them are feature meets. U.C.L.A. appears at Tournament Park on April 1 in the first dual meet of the season. On April 15 the Beavers play host to the U.S.C. Trojans, while the Pasadena Games, a large open meet on June 10, closes the schedule.

TRACK SCHEDULE

Sat. April 1	U.C.L.A.	at Caltech
Sat. April 8	College Relays	at Occidental
Sat. April 15	U.S.C.	at Caltech
Sat. April 22	Open College Meet	at Coliseum
Sat. April 29	Caltech	at Occidental
Sat. May 6	Caltech	at Redlands
Sat. May 20	Southern California Conference Meet	at Occidental
Sat. May 27	Southern California Invitational	at Coliseum
Sat. June 3	Caltech, Redlands, Pepperdine, Occidental	at U.C.L.A.
Sat. June 10	Pasadena Games	at Caltech

BASEBALL SCHEDULE

Sat. April 8	Pepperdine	at Caltech
Sat. April 15	Caltech	at U.C.L.A.
Sat. April 22	Occidental	at Caltech
Sat. April 29	Caltech	at U.S.C.
Sat. May 6	Caltech	at Redlands
Sat. May 13	U.C.L.A.	at Caltech
Sat. May 20	Redlands	at Caltech
Sat. May 27	Caltech	at Pepperdine

*Acting director of physical education.

Sat. June 3	Caltech	at Occidental
Sat. June 10	U.S.C.	at Caltech

SWIMMING

Sat. May 13	Intercollegiate Championships	at U.C.L.A.

TENNIS

Sat. May 20	Intercollegiate Championships	at U.C.L.A.

GOLF

Sat. May 20	Intercollegiate Championships	at U.C.L.A.

TECH ALUMNI IN WASHINGTON MEET

ON THE evening of January 13, 44 Tech alumni who are now living in the Washington area met at Schneider's Cafe in Washington for dinner. Most of the evening was spent in getting acquainted with the other fellow and the occasion promised to be the first in a series of dinner meetings to be held at intervals of about three months.

The idea of the meeting originated with Fred Groat, '24, who realized that there are now many Tech men in and around Washington. At a short business session at the close of the dinner, Mr. Groat was elected temporary chairman of the group to plan future meetings. Major Paul Engelder, U.S.M.C., '38, has consented to be the speaker for the March meeting.

Dr. Royal W. Sorensen and Frank Streit, '26, both now at Columbia University, New York, were guests. Dr. Sorensen gave an interesting summary of affairs at the Institute during the past academic year.

Any alumni in the Washington area may contact the group by calling any of the following:

Fred Groat — Home: EMerson 0295; Office: REpublic 7500, Ext. 2425.

Doug Tellwright—Home: ORdway 4662; Office: REpublic 6700, Ext. 71348.

Wayne Rodgers—Home: REpublic 0461, Apt. 201; Office, REpublic 6700, Ext. 3649.

Bob Vaile—Home: FRanklin 8300, Ext. 420; Office: FRanklin 5700, Ext. 2326.

Those present and their business or military connection were Lucas A. Alden, '31, War Production Board; Maurice A. Biot, '32, Lieutenant, U.S.N.R.; David R. Arnold, '43, Ensign, U.S.N.R.; James Boyd, '27, Colonel, C. E.; Wayne H. Brown, '43, Ensign, U.S.N.R.; Michael C. Brunner, '25, Lieutenant Colonel, C.E.; Everett F. Cox, '33, Navy Department; Harry E. Cunningham, '26, Public Roads Administration; Thomas Evans, '29, Major, C.E.; Al B. Focke, '32, Navy Department; Mark G. Foster, '39, Navy Department; C. Lewis Gazin, '27, Captain A.C.; Martin J. Gould, '41, Navy Department; Albert P. Green, '39, Navy Department; Lowell F. Green, '31, Navy Department; Fred J. Groat, '24, War Production Board; Ben C. Haynes, '32, Weather Bureau; John K. Hiss, '33, Navy Department; John W. Jackson, '40, University of Maryland; J. Edward Joujon-Roche, '28; Peter H. Kafitz, '42, Navy Department; Ray F. Labory, '31, Lieutenant, U.S.N.R.; Albert E. Lombard, Jr., '28, Aircraft Resources; Laurence E. Lynn, '29, Lieutenant Colonel, C.E.; Robert E. MacKenzie, '42, Navy Department; William B. McLean, '35, Bureau of Standards; James T. Mercereau, '24, Lieutenant Colonel; Clinton T. Newby, '40, Lieutenant, U.S.N.R.; Norman P. Oldson, '40, Navy Department; John S. Rinehart, '37, National Defense Research Committee; V. Wayne Rodgers, '27, Major, C.E.; L. H. Rumbaugh, '32, Navy Department; Carl G. Schrader, '40, Navy Department; David Sheffet, '30, Navy Department; E. W. Silvertooth, '40, Navy Department; Zaka I. Slawsky, '35, Navy Department; Milton M. Slawsky, '35, Navy Department; Thomas S. Southwick, '27, Captain, C.E.; Cedric W. Stirling, '43, Lieutenant Commander, U.S.N.; Frank Streit, '26, Columbia University; F. Douglas Tellwright, '24, Army and Navy Electronics Production Agency; Robert B. Vaile, '27, Navy Department; M. Van Reed, '32, First Lieutenant, C.E.; Baker Wingfield, '28, Public Buildings Administration.

PERSONALS

1923

LOREN BLAKELEY is recuperating from an attack of infantile paralysis which has kept him from his work since last July. As secretary of the class of 1923, he is anxious to complete the roll call of the class which was begun in an earlier issue of Engineering and Science.

1926

A. M. BALL was a recent visitor to the campus and to southern California war plants in connection with his duties as technical director of the Hercules Powder Company.

W. A. LEWIS, formerly director of the School of Electrical Engineering at Cornell University, has resigned to return to the field of engineering research. He has been named consulting electrical engineer to the Armour Research Foundation at the Illinois Institute of Technology, Chicago, and is also a research professor in the electrical engineering department.

1927

EDWARD M. BROWDER is structural engineer for the department of operations and maintenance of the Panama Canal and is serving as president of the Panama section of the American Society of Civil Engineers.

1928

DR. ALBERT E. LOMBARD, JR., is a special assistant to the director of the Aircraft Resources Control Office at the Pentagon Building, Washington, D. C.

1929

FRANK W. THOMPSON was commissioned a lieutenant senior grade, U.S.N.R., in May, 1942. He received his training at Newport, R. I., and at the naval gun factory at Washington, D. C. He was stationed in the planning section of the Bureau of Ordnance but was later transferred to his present position in the industrial manager's office of the department of design for the repair and conversion of ships, at the 11th Naval District in San Diego.

ALBERT C. REED has moved to Pasadena after having been chief test pilot for Boeing Aircraft in Seattle.

1930

AL VOAK is in the industrial engineering department of Firestone in Los Angeles.

ERNEST LEVINE is project manager for Contracting Engineers Company in charge of the completion of the $5,000,000 Aliso Street Viaduct over the Los Angeles River.

LIEUTENANT F. T. SWIFT is a radio officer in the Navy and is stationed at a Pacific base.

1934

SID SMITH is in the South Pacific, employed by Submarine Signal Company as a United States technician, doing work for the United States Navy. He is married and has two small sons.

1936

WASSON NESTLER was recently promoted to captain in the Army Signal Corps. He visited his family recently in San Marino, and they returned with him to Florida where he is stationed at Drew Field.

1937

ERNEST MONCRIEF is a process engineer at the Fluor Corporation.

FREDERIC DION, JR., is with the engineering department of Joseph E. Seagram and Sons, Inc., at Louisville, Ky., where his present activities are centered on a program of expanding alcohol production. In October he married Miss V. Elizabeth Myers of Clifton, Va.

MAJOR JOHN H. BLUE, U.S.M.C., returned recently from an overseas assignment of 21 months.

1938

STANLEY WOLFBERG and Miss Lois Rubin were married on January 17 at San Francisco.

1939

LIEUTENANT ROD McCLUNG is at Champaign, Ill.

LIEUTENANT BYRON BEANFIELD, U.S.N.R., is now with the Office Inspector of Naval Materiel at Philadelphia, Pa.

1940

JAMES WHITTLESEY has been an ensign in the Navy since May, 1943. He is now at the Naval Air Station in Seattle.

JOSEPH MANILDI and Miss Shirley Jacobs were married in February. He is employed at the Institute.

1941

JOHN B. HIATT, Ensign, U.S.N.R., was married to Miss Agnes Liesch at Bremerton, Wash.

1942

LIEUTENANT FRANK FLECK met LIEUTENANT JOHN PARKER, '38, while in Champaign, Ill. They are both Army Air Force navigators.

WENDELL W. HARTER was married in Pasadena on February 26 to Miss Madelyn Pyle, and they are now living in Los Angeles. She is continuing her studies at U.C.L.A. and he is employed as a stress engineer at Northrop.

LIEUTENANT (j.g.) ERWIN R. LARSON, U.S.N.R., has been in the South Pacific for over a year and a half.

ALAN GROSSBERG is employed in the chemistry department at the Institute.

THOMAS CURTIS is teaching at the Institute.

1943

EARL LONG and Miss Patricia Wiseman were married on January 8, 1944. He is employed by North American Aviation, Inc. Mrs. Long was a Rose Princess in the 1942 Tournament of Roses.

MALCOLM MASON is an ensign in the U.S.N.R., and is located at Fort Schuyler, N. Y.

HUGH GRAHAM completed a course recently as an Army Air Corps engineering cadet at Yale University.

PAUL WITTIG, ex-'43, was employed, after leaving Tech, as a production engineer at Bell Aircraft in Buffalo. He recently joined the Army Air Corps.

SAMUEL P. MORGAN, JR., is now a teaching fellow in the physics department at the Institute, after having spent a year at the physics department of the University of California at Berkeley.

WILLIAM H. McNEELY is attending Ohio State University where he holds a postdoctorate fellowship.

RICHARD B. ESCUE, JR., is physicist in charge of the spectrophotometric laboratory at Neches Butane Products Company, Port Neches, Texas. He recently attended the rubber reserve conference in Los Angeles.

ENSIGN ALLEN D. WEEKS, U.S.N.R., after completion of a four months ordnance training course in Washington, D. C., has been following a course of instruction at several large instrument companies in the East. At present he is with the York Safe and Lock Company, York, Pa.

OSCAR TERRELL and Miss Jean Hadley of Altadena were married February 20 at Kingman, Ariz. He was employed with the Merchant Marine but now is working at the Institute.

JOHN FRENCH is employed as an instructor at the Institute.

1944

JOE BRUMAN will remain for further work at the Institute.

DEAN CHAPMAN plans to teach math at the Institute until June and then join Curtiss-Wright Corp. at Passaic, N. J.

A. JOHN A. MORGAN and JOHN MARSHALL are with Lockheed Aircraft Corp.

FRANK SMITH, JR., has joined the U. S. Navy Bureau of Aeronautics.

JAMES R. ST. JOHN will study medicine.

JAMES PLOESER is employed by the Massachusetts Institute of Technology Development Laboratory.

CORNELIUS STEELINK is with the Shell Chemical Company, Dominguez, Calif.

GARMON HARBOTTLE is remaining at the Institute to be employed in the chemistry department.

CARL O. MATTINSON is at the Massachusetts Institute of Technology.

FRANCIS ODELL is employed by the chemical engineering department at Caltech.

JOHN B. NELSON is returning to his home at Honolulu, T.H., where he will be employed by the Honolulu Gas Company.

CRAN BARROW is at Knoxville, Tenn., with the Eastman Kodak Company.

ARTHUR N. CARSON is employed by Sperry Gyroscope.

HOWARD CHANG is attending the Massachusetts Institute of Technology graduate school.

CHARLES COX is a research assistant with the Kellogg Laboratory at Caltech.

THOMAS GILBERT is with Armour Research.

ALOIS SCHARDT is returning to Caltech on a fellowship.

JAY HAMMEL is a physicist at Eastman Kodak, Clinton, Tenn.

DANIEL BOTKIN is with the chemical engineering department at the Institute.

ROBERT THOMAS returned to the Institute on a fellowship.

ALAN ANDREW is with the physics department at the Institute.

WILLIAM OLENBUSH is with the Standard Oil Company.

WESLEY R. SANDELL is with Chemical Warfare, Massachusetts Institute of Technology.

ELMER S. HALL has joined the Westinghouse Electric and Manufacturing Company.

OWEN OLDS is with Allis-Chalmers, Milwaukee, Wis.

DAVID RUTLAND is remaining at the Institute, and is employed by N.D.R.C.

DOYLE WILCOX is with Consolidated Engineering Corporation in Pasadena.

STANLEY DAY is in Wallace, Utah, with the Tamarach and Custer Consolidated Mining Company.

CHARLES G. ALMQUIST is in Flint, Mich., with General Motors.

TWAY ANDREWS is employed by the Norris Stamping Company, Los Angeles.

HAROLD V. CURCI is with Shell Chemical Company.

DAVID JONES is with the Standard Oil Company.

KEITH DITMAN expects to study medicine while in the Army.

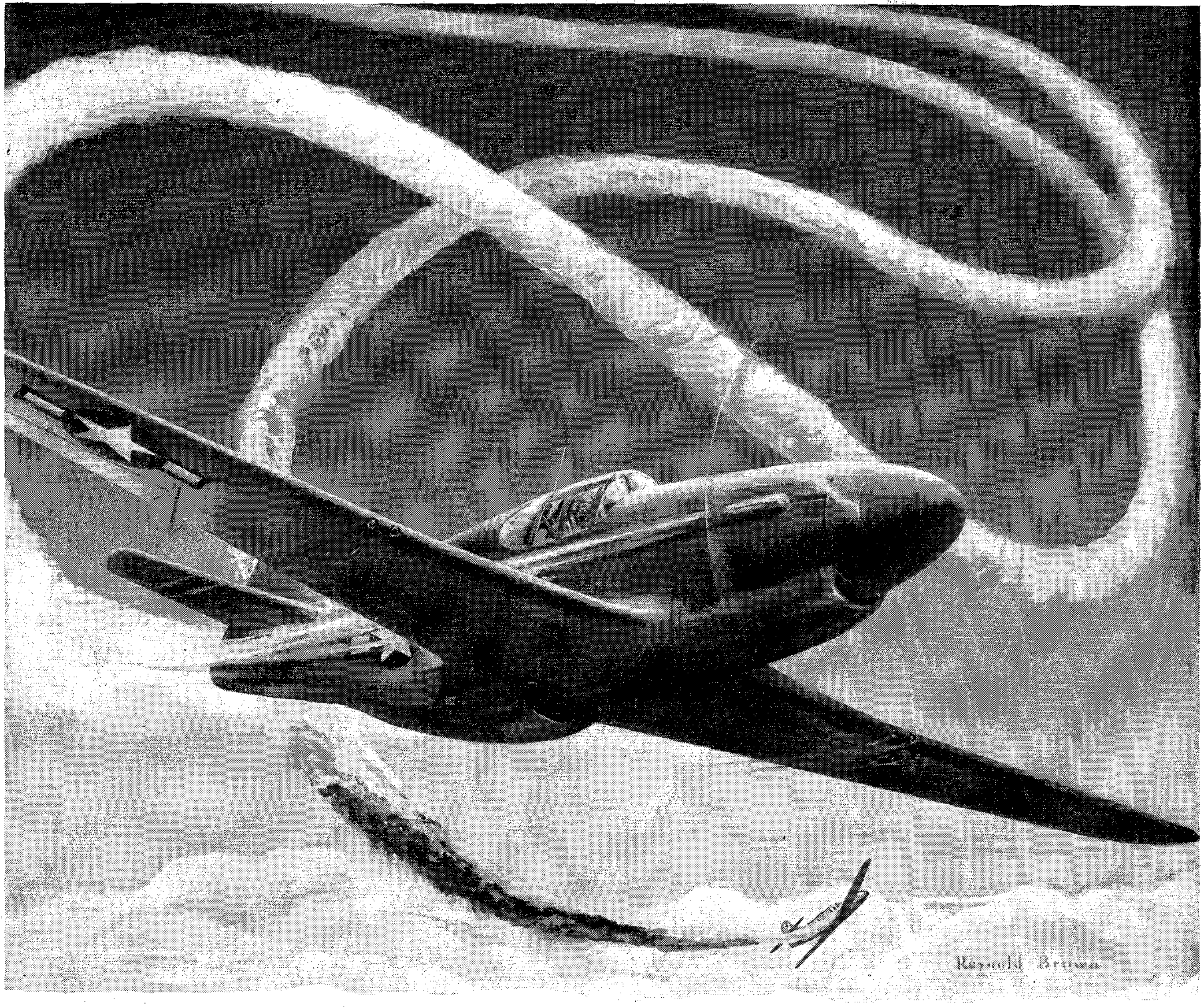
WILLARD A. DODGE, JR., joined the Army in February.

WALTER FILLIPONE is with the United Geophysical Company.

ENRIQUE SILGADO plans to return to Peru.

PAUL LABANAUSKAS is employed by the General Electric Company.

ENSIGN HARRISON SIGWORTH completed his midshipman's training at Columbia University recently and visited the campus while on leave before reporting for sea duty.



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